VOLUME 78 • JUNE 1959 • NUMBER 6

A.M.A. ARCHIVES OF

SURGERY

INDEX NUMBER

Management of Chylous Extravasation
Walter J. Burdette

Control of Gastric Secretion by the Antrum
R. C. Harrison, F. Gomes, and H. J. Shimizu

Diphasic Blood Ammonia Curves After Feeding Protein to Normal Dogs and Men
James S. Clarke, Kenneth Cruze, Paul K. McKissock, and Robert S. Ozeran

Control of Ammonia Production in the Colon with Neomycin Enemas
John S. Najarian, Jack Jew, Richard L. Dakin, Harold A. Harper, Clara M. Quinnell, and H. J. McCorkle

Clinical Use of Intravenous Fat in Surgical Patients
William H. Marshall

Temporary Exclusion of Liver from the Circulatory System
Richard L. Dakin, Jack Jew, Harold A. Harper, and H. J. McCorkle

In Vitro Incorporation of Rb^{86} by the Erythrocyte as an Index of Intracellular Potassium
George C. Henegar, Roger W. Friskey, and Frederick W. Preston

Adjuncts in Hernial Repair
Robert S. Smith

Relationship of Peptic Esophagitis to Spontaneous Rupture of Esophagus
John M. Dorsey, Robert P. Hohf, and Thomas E. Lynn

Balanced Operations for Esophagitis Associated with Esophageal Hiatal Hernia
Jacob K. Berman and Edward J. Berman

Peptic Ulcer and Pulmonary Emphysema
William Silen, William H. Brown, and Ben Eiseman

Use of Gastrostomy in Pediatric Surgery
Lester W. Martin and C. Thomas Fultz

Strictures of the Common and Hepatic Bile Ducts
Waltman Walters, James W. Nixon Jr., Thomas E. Hodgins, and John A. Ramsdell

Freedom from Pain After Hemorrhoidectomy
Willard Bartlett

Eosinophilic Granuloma of Ileum
Elmer W. Koneman, Kenneth C. Sawyer, and Alexis E. Lubchenco

Hypertrophy of Ileocecal Valve
Mohammed H. Salem and Harry H. McGee

Meckel's Diverticulum
Claude W. Barrick and Kenneth E. Fry

Extensive Aortic-Iliac-Femoral Grafting
W. Andrew Dale

Gastric Trichobezoar
C. Herbert Fredell

Blood Pressure Changes in Paraplegics During Urological Manipulations
Rodney A. Mannion, Thomas L. C. Cottrell, and Frederick A. Lloyd

Acute Intestinal Obstruction Secondary to Postoperative Adhesions
Edward M. Miller and James M. Winfield

Wound Healing
Raymond W. Postlethwait, James E. Schauble, Marcus L. Dillon, and Joseph Freeman

Use of Suction in Control of Residual, Infected, or Draining Cavities, Tracts, and Fistulas
Kermit O. Vandenbos, Carl W. Hughes, and Warner F. Bowers

Gallstones and Pregnancy
Alfred M. Large, James E. Lofstrom, and Charles S. Stevenson

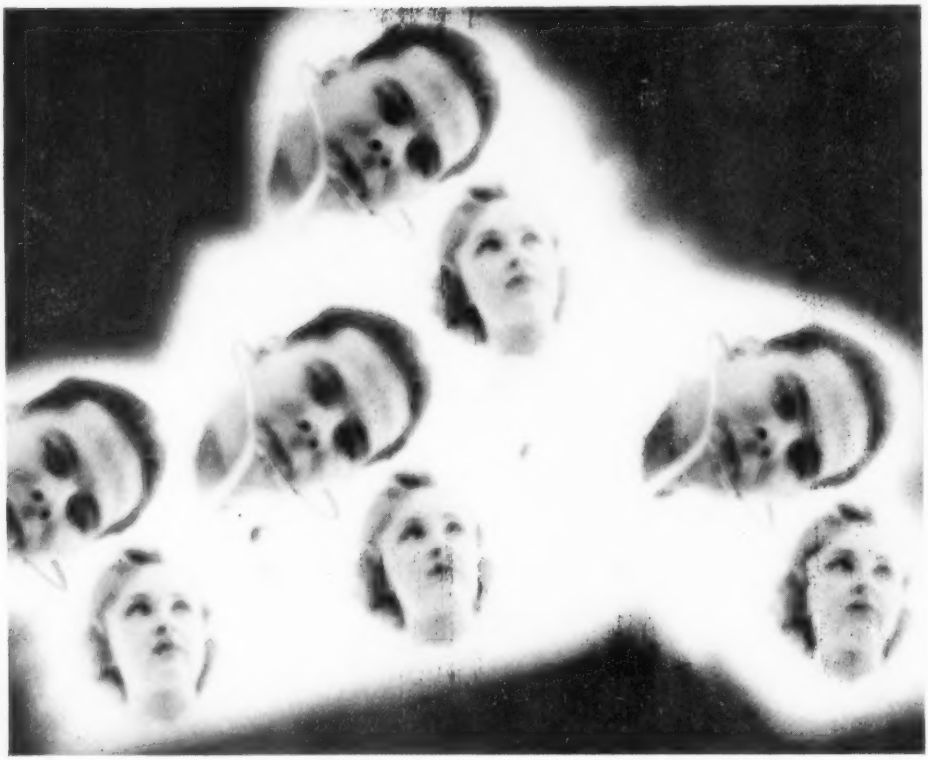
Successfully Resected Leiomyoma of Jejunum in a Newborn
Andrew B. Breuder, Alvin R. Mintz, Harald J. Schwarz, and Earl D. Stage

Spontaneous Cholecystocholedochal Fistula
Church E. Murdock Jr.

Benign Retroperitoneal Mesenchymoma (Hamartoma)
H. Richard Hellstrom and Edwin R. Fisher

AMERICAN MEDICAL ASSOCIATION PUBLICATION

In postoperative nausea and vomiting...



Dramamine®

brand of dimenhydrinate

no matter what the patient's condition, Dramamine can be easily administered

Prevent or treat emesis following surgery or administration of narcotics with whichever form of Dramamine is indicated. If your patient will not take oral medication or if acute vomiting, restlessness or the patient's condition make oral Dramamine impractical . . . Dramamine parenterally (ampuls) or rectally (Supposicones) will bring rapid relief.

the only antinauseant in 4 dosage forms

Tablets Ampuls Liquid Supposicones®

SEARLE

TABLE OF CONTENTS

VOLUME 78 JUNE 1959 NUMBER 6

PAPERS READ AT SIXTY-SIXTH ANNUAL MEETING OF THE WESTERN SURGICAL ASSOCIATION, ROCHESTER, MINN., NOV. 20, 21, AND 22, 1958 CONCLUDED

ORIGINAL ARTICLES

PAGE

Management of Chylous Extravasation
Walter J. Burdette, Ph.D., M.D., Salt Lake City 815

Control of Gastric Secretion by the Antrum
R. C. Harrison, M.D. F.R.C.S.(C); F. Gouws, M.D., and H. J. Shimizu, M.D., Edmonton, Alta., Canada 832

Diphasic Blood Ammonia Curves After Feeding Protein to Normal Dogs and Men
James S. Clarke, M.D.; Kenneth Cruze, M.D.; Paul K. McKissock, M.D., and Robert S. Ozeran, M.D., Los Angeles 836

Control of Ammonia Production in the Colon with Neomycin Enemas
John S. Najarian, M.D.; Jack Jew, M.D.; Richard L. Dakin, M.D.; Harold A. Harper, Ph.D.; Clara M. Quinnell, Ph.D., and H. J. McCorkle, M.D., San Francisco 844

Clinical Use of Intravenous Fat in Surgical Patients
William H. Marshall, M.D., Chicago 851

Temporary Exclusion of Liver from the Circulatory System
Richard L. Dakin, M.D.; Jack Jew, M.D.; Harold A. Harper, Ph.D. and H. J. McCorkle, M.D., San Francisco 856

In Vitro Incorporation of Rb^{86} by the Erythrocyte as an Index of Intracellular Potassium
George C. Henegar, M.D.; Roger W. Friskey, M.D., and Frederick W. Preston, M.D., Chicago 862

Adjuncts in Hernial Repair
Robert S. Smith, M.D., Boise, Idaho 868

Relationship of Peptic Esophagitis to Spontaneous Rupture of Esophagus
John M. Dorsey, M.D.; Robert P. Hohf, M.D., and Thomas E. Lynn, M.D., Evanston, Ill. 878

Balanced Operations for Esophagitis Associated with Esophageal Hiatal Hernia
Jacob K. Berman, M.D., and Edward J. Berman, M.D., Indianapolis 889

Peptic Ulcer and Pulmonary Emphysema
William Silen, M.D.; William H. Brown, M.D., and Ben Eiseman, M.D., Denver 897

Use of Gastrostomy in Pediatric Surgery
Lester W. Martin, M.D., and C. Thomas Fultz, M.D., Cincinnati 904

Strictures of the Common and Hepatic Bile Ducts
Waltman Walters, M.D.; James W. Nixon Jr., M.D.; Thomas E. Hodgins, M.D., and John A. Ramsdell, M.D., Rochester, Minn. 908

Freedom from Pain After Hemorrhoidectomy
Willard Bartlett, M.D., St. Louis 916

Eosinophilic Granuloma of Ileum
Elmer W. Koneman, M.D.; Kenneth C. Sawyer, M.D., and Alexis E. Lubchenco, M.D., Denver 923

Hypertrophy of Ileocecal Valve
Mohammed H. Salem, M.B., B.Ch., and Harry H. McGee, M.D., Durham, N. C. 928

Meckel's Diverticulum
Claude W. Barrick, M.D., and Kenneth E. Fry, M.D., Philadelphia 934

Extensive Aortic-Iliac-Femoral Grafting
W. Andrew Dale, M.D., Nashville, Tenn. 937

Gastric Trichobezoar
C. Herbert Fredell, M.D., Flagstaff, Ariz. 946

(Continued on next page)

A. M. A. ARCHIVES OF SURGERY

Also the Official Publication of the Central Surgical Association and the Western Surgical Association

VOLUME 78 JUNE 1959 NUMBER 6

COPYRIGHT, 1959, BY THE AMERICAN MEDICAL ASSOCIATION

EDITORIAL BOARD

WALTMAN WALTERS, Chief Editor, Rochester, Minn.

J. GARROTT ALLEN, Chicago
ALFRED BLALOCK, Baltimore
FRANK HINMAN Jr., San Francisco
G. E. LINDSKOG, New Haven, Conn.
WALTER MADDOCK, Chicago
ALTON OCHSNER, New Orleans
HENRY KING RANSOM, Ann Arbor, Mich.
HENRY SWAN, Denver
RICHARD WARREN, Boston

BARNES WOODHALL, Durham, N. C.

J. F. HAMMOND, Editor, A. M. A. Scientific Publications
GILBERT S. COOPER, Managing Editor, Specialty Journals

TABLE OF CONTENTS (Continued)

Blood Pressure Changes in Paraplegics During Urological Manipulations
Rodney A. Mannion, M.D.; Thomas L. C. Cottrell, M.D., and Frederick A. Lloyd, M.D., Hines, Ill. 949

Acute Intestinal Obstruction Secondary to Postoperative Adhesions
Edward M. Miller, M.D., and James M. Winfield, M.D., New York 952

Wound Healing
Raymond W. Postlethwait, M.D.; James F. Schauble, M.D.; Marcus L. Dillon, M.D., and Joseph Freeman, M.D., Durham, N. C. 958

Use of Suction in Control of Residual, Infected, or Draining Cavities, Tracts, and Fistulas
Capt. Kermit Q. Vandenbos (MC), U. A. A. F.; Lt. Col. Carl W. Hughes (MC), and Col. Warner F. Bowers (MC), U. S. Army 962

Gallstones and Pregnancy
Alfred M. Large, M.D.; James E. Lofstrom, M.D., and Charles S. Stevenson, M.D., Detroit 966

CASE REPORTS

Successfully Resected Leiomyoma of Jejunum in a Newborn
Andrew B. Breuder, M.D.; Alvin R. Mintz, M.D.; Harald J. Schwarz, M.D., and Earl D. Stage, M.D., Morristown, N. J. 969

Spontaneous Cholecystocholedochal Fistula
Church E. Murdock Jr., M.D., Mobile, Ala. 972

Benign Retroperitoneal Mesenchymoma (Hamartoma)
H. Richard Hellstrom, M.D., and Edwin R. Fisher, M.D., Pittsburgh 975

Published monthly by the AMERICAN MEDICAL ASSOCIATION. Editorial and Circulation Offices: 535 North Dearborn Street, Chicago 10, Illinois. Publication Office: Thompson Lane, Box 539, Nashville 1, Tennessee.

Second-class postage paid in Nashville, Tennessee.

CHANGE OF ADDRESS: When there is a change of address, the Circulation Office of the American Medical Association should be notified at least six weeks before the change is made. The address label clipped from the subscriber's latest copy of the publication and a statement of old and new address should be included. If there is a postal zone number, it too should be included in the new address. The instructions should state whether the change is permanent or temporary.

around the clock ulcer control with **B.I.D.** *dosage*

Just one 10 mg. Daricon tablet in the morning, and one at night before retiring, keeps your patient free from the pain and discomfort caused by gastrointestinal spasm, hypermotility, and hypersecretion.

Daricon is a remarkably potent and well tolerated antisecretory/antimotility agent. Its *naturally* prolonged action provides day and night relief of pain and symptoms associated with peptic ulcer, functional bowel syndrome, biliary tract dysfunctions, ulcerative colitis, and other gastrointestinal disorders characterized by spasm, hypermotility, and hypersecretion.

Dosage: 10 mg. b.i.d. (morning and evening).

SOME REFRACTORY CASES RESPOND

new **DARICON***

oxyphencyclimine HCl

Pfizer *Science for the world's well-being*

Pfizer Laboratories
Division, Chas. Pfizer & Co., Inc.
Brooklyn 6, New York

References: 1. Finkelstein, M., et al.: J. Pharmacol. & Exper. Therap. 125:330 (April) 1959. 2. McHardy, G., et al.: Postgrad. Med., in press. 3. Winkelstein, A.: Amer. J. Gastroenterol., in press. 4. Finkelstein, M., et al.: Presented at Fall Meeting, Amer. Soc. Pharmacol. & Exper. Therap., 1958. 5. Leming, B.: Clin. Med. 6:423 (March) 1959.

*Trademark

Instructions to Contributors

Articles, book reviews, and other materials for publication should be addressed to the Chief Editor. Articles are accepted for publication on condition that they are contributed solely to this journal.

An original typescript of an article, with one carbon copy, should be provided; it must be double or triple spaced on one side of a standard size page, with at least a 1-inch margin at each edge. Another carbon copy should be retained by the author.

The main title of an article may not contain more than eighty characters and spaces; a subtitle may be of any length.

The author's name should be accompanied by the highest earned academic or medical degree which he holds. If academic connections are given for one author of an article, such connections must be given for all other authors of the article who have such connections.

If it is necessary to publish a recognizable photograph of a person, the author should notify the publisher that permission to publish has been obtained from the subject himself if an adult, or from the parents or guardian if a child. An illustration that has been published in another publication should be accompanied by a statement that permission for reproduction has been obtained from the author and the original publisher.

Oversized original illustrations should be photographed and a print on glossy paper submitted. Prints of a bluish tinge should be avoided. Large photomicrograph prints will be reduced in scale unless portions to be cropped are indicated by the author. The author should submit duplicate prints of roentgenograms and photomicrographs with the essential parts that are to be emphasized circled, as a guide to the photoengraver.

Charts and drawings should be in black ink on hard, white paper. Lettering should be large enough, uniform, and sharp enough to permit necessary reduction. Glossy prints of x-rays are requested. Paper clips should not be used on prints, since their mark shows in reproduction, as does writing on the back of prints with hard lead pencil or stiff pen. Labels should be prepared and pasted to the back of each illustration showing its number, the author's name, and an abbreviated title of the article, and plainly indicating the top. Charts and illustrations must have descriptive legends, grouped on a separate sheet. Tables must have captions. ILLUSTRATIONS SHOULD BE UNMOUNTED.

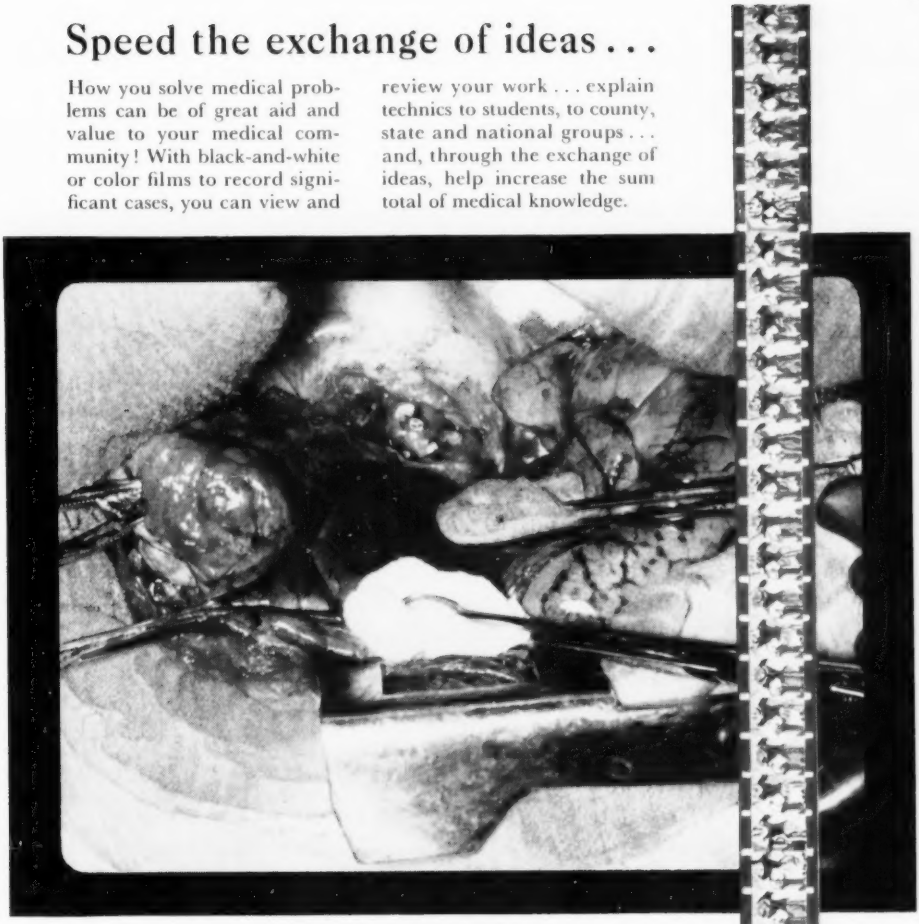
References to the literature should be limited to those used by the author in preparation of the article. They should be typed on a special page at the end of the manuscript. The citation should include, in the order given, name of author, title of article (with subtitle), name of periodical, with volume, page, month—day of month if weekly or biweekly—and year. References to books must contain, in the order given, name of author, title of book, city of publication, name of publisher, and year of publication.

AMERICAN MEDICAL ASSOCIATION

535 North Dearborn Street **Chicago 10**

Speed the exchange of ideas . . .

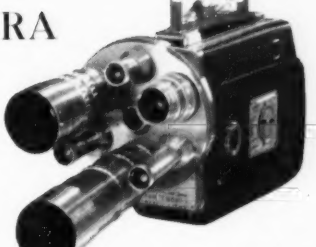
How you solve medical problems can be of great aid and value to your medical community! With black-and-white or color films to record significant cases, you can view and review your work . . . explain technics to students, to county, state and national groups . . . and, through the exchange of ideas, help increase the sum total of medical knowledge.



. . . with this precision 16mm
CINE-KODAK K-100 CAMERA

Medical motion pictures of the highest quality are easily within the scope of the K-100 Turret Model. The film runs quietly, smoothly—40 feet at one winding. And you have available a complete series of Kodak Cine Ektar Lenses. Any three lenses can be mounted on the turret for instant changing.

The Cine-Kodak K-100 Turret Camera is priced from $337 (single-lens model from $299).



For further details, see your Kodak photographic dealer or write:

Prices are list, include Federal Tax where applicable, and are subject to change without notice.

EASTMAN KODAK COMPANY, *Medical Division*, Rochester 4, N.Y.

Serving medical progress through Photography and Radiography

Kodak
TRADE MARK

PUBLISHED MAY 1: VOLUME 10

ANNUAL REVIEW OF MEDICINE

Editors: D. A. Rytand
W. C. Creger

Editorial Committee:
R. E. Cooke
W. C. Cutting
G. J. Dammin
M. A. Hayes
D. A. Rytand
E. A. Stead, Jr.

". . . merits praise as a useful guide to the serious investigation in almost every field of medicine." *The Am. Jnl. of Clinical Nutrition, Vol. 6, No. 6, Nov.-Dec., 1958.*
"These excellent reviews should be useful to all students of medicine regardless of their training or special interests." *Med. Services Jnl., Canada, Dec. 1958.*

CONTENTS

Infectious Diseases (Some Aspects of Salmonellosis) ..... *I. L. Bennett, Jr. and E. W. Hook*
Gastroenterology ..... *J. B. Kirsner, J. E. Dooley, G. E. Scott and S. C. Kraft*
Diseases of the Cardiovascular System (Excluding Hypertension and Atherosclerosis), *F. D. Johnston*
Cardiovascular Diseases (Atherosclerosis) ..... *W. Dock*
Diseases of the Cardiovascular System (Surgical) ..... *D. E. Harken and W. J. Taylor*
Nutrition and Nutritional Diseases ..... *G. H. Berryman*
Endocrinology (Diabetes) ..... *H. T. Ricketts*
Endocrinology (Reproduction) ..... *R. L. Landau*
Endocrinology (Surgery of the Endocrines) ..... *J. D. Hardy*
Allergy and Immunology ..... *W. B. Sherman*
Neoplastic Diseases (Cancer) ..... *C. Oberling*
Neoplastic Diseases (Tumor Chemotherapy) ..... *R. L. Clark, Jr. and W. W. Sutow*
Diseases of the Nervous System ..... *R. N. DeJong*
Psychiatry ..... *T. A. Gonda*
Special Therapeutics (Transfusions) ..... *S. C. Finch*
Diseases of the Skin ..... *S. W. Becker, Jr.*
Pediatrics (Noncardiac Anomalies) ..... *M. M. Ravitch and R. J. Wilder*
Diseases of the Respiratory System ..... *R. S. Mitchell and G. C. Bower*
Environmental Medicine ..... *R. A. Kehoe, L. H. Miller, A. Davis and M. Zavon*

448 pages subject and author indexes back volumes available
$7.00 postpaid (U.S.A.); $7.50 postpaid (elsewhere)

Published March, 1959: ANNUAL REVIEW OF PHYSIOLOGY, VOL. 21

V. E. Hall, F. A. Fuhrman, A. C. Giese, Editors 636 pages
Most back volumes available Same price as above

ANNUAL REVIEWS, INC. 231 Grant Avenue, Palo Alto, California

in surgical, therapeutic,
and diagnostic procedures
specific advantages
• rapid, smooth induction
• evenly sustained surgical plane of anesthesia
• prompt, pleasant recovery
• relative freedom from laryngospasm and bronchospasm
SURITAL®
SODIUM
ultrashort-acting intravenous anesthetic
Detailed information on SURITAL Sodium (thiamylal sodium, Parke-Davis) is available on request.
PARKE, DAVIS & COMPANY
Detroit 32, Michigan

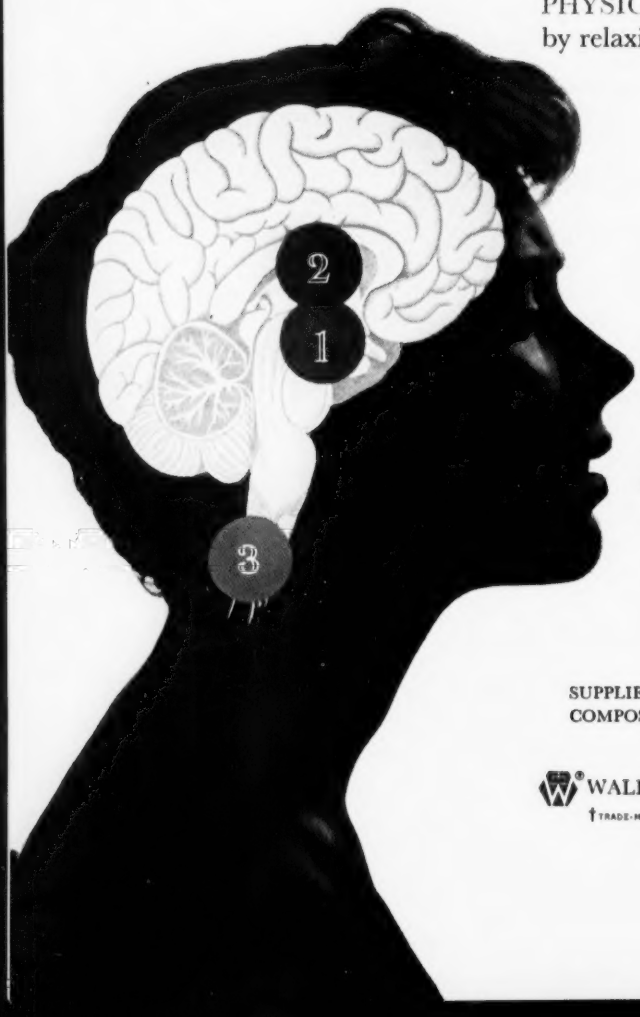
COMPREHENSIVE, THREE-LEVEL TREATMENT OF DEPRESSION

AND ASSOCIATED ANXIETY AND PHYSICAL TENSION

RELIEVES DEPRESSION
including symptoms such as crying, lethargy, loss of appetite, insomnia

RELIEVES ASSOCIATED ANXIETY
with no risk of drug-induced depression

RELIEVES ASSOCIATED PHYSICAL TENSION
by relaxing skeletal muscle



1
hypothalamus

2
thalamus and limbic system

3
spinal cord

▲Deprol▲†

benactyzine + meprobamate

- confirmed efficacy
- documented safety

SUPPLIED: Bottles of 50 light-pink, scored tablets
COMPOSITION: Each tablet contains 1 mg. benactyzine HCl and 400 mg. meprobamate

WALLACE LABORATORIES • *New Brunswick, N. J.*

†TRADE-MARK

CD-9290

A.M.A. ARCHIVES OF
SURGERY

Management of Chylous Extravasation

WALTER J. BURDETTE, Ph.D., M.D., Salt Lake City

The extravasation of chyle into thoracic and abdominal cavities has been recognized as a clinical problem since the 17th century. Shortly after publication of the clinical studies of Asellius,[4] reports of traumatic chylothorax were mentioned by Bartolet[109] in 1633, by Longelot[6] in 1663, and by de Diemerbroeck[44] in 1685, and a detailed description of the condition was given by Quincke[132] in 1875. In 1691 Morton[7,93] described chylous ascites in a boy of 2 years, who eventually died following withdrawal of fluid from the abdominal cavity. Following clinical observations on obstruction of the thoracic duct, Sir Astley Cooper[31] performed experiments on the effects of ligation and reported his findings in 1798.

A number of reviews with collected cases have appeared. Busey[24] recorded 53 cases of chylous ascites and reported them in 1889. Wallis and Schölberg[163] collected 173 cases of "milky ascites," 3 of which were of infants under one year of age. Cowie[32] reported one case of his own in 1911 and mentioned eight additional cases. Gribetz and Kanof[67] collected 25 cases of chylous ascites in infancy and reported a case of their own with chylocele. Zesas[171,172] collected 18 cases of traumatic chylothorax in 1912, to which McNab[109] added 15 cases in 1932; and in 1938 Shackelford and Fisher[145] added 8 cases plus 6 additional cases not described in detail. Yater[179] reviewed the cases of nontraumatic chylothorax in 1935, and by 1957 Garamella[65] was able to report 40 cases in which the thoracic duct had been ligated without mortality. Loe,[99] in 1946, noted 62 cases of chylothorax in the literature, and reported a case of his own in which the thoracic duct was ligated following a bullet wound in the neck. Fourteen cases of injury to the thoracic duct in the cervical region were reported by Allen and Briggs[2,40] in 1901, and 31 cases of operative damage to the duct in the neck were reported by De Forest[41] in 1907.

Recently, three cases of chylous extravasation were encountered within a period of a few months, and the details of these examples of the condition are recorded in the present report. Only four cases were found among the records of the five hospitals with which the University of Utah is affiliated, representing an aggregate of 1,429 beds and 225,371 admissions during the period in which the records were compiled. The incidence of chylous extravasation in the series, therefore, is 1 case in 56,343 admissions.

Report of Cases

CASE 1.—*Chief Complaint.*—The patient, a 26-year-old white married machine operator, was admitted for treatment of ascites (Fig. 1*A*) on Feb. 24, 1958.

Present Illness.—In January, 1958, the patient required admission because of chylous ascites, which had recurred after a free interval of three months. Paracentesis yielded 10,150 ml. of chyle on Feb. 1, 1958; 11,400 ml. on Feb. 10, and 8,700 ml. on

Department of Surgery, University of Utah College of Medicine.

Read at the 66th Annual Meeting of the Western Surgical Association, Rochester, Minn., Nov. 21, 1958.

Feb. 17. Because of this alarming development in the course of the patient's illness, a consultation was requested for surgical intervention in this case. Each time the fluid accumulated, the patient had extreme dyspnea and abdominal cramps but had no fever, chills, itching, cough, or hemoptysis.

Past History.—Five and one-half years prior to admission, the patient had a right pleural effusion, which caused minimal symptoms and developed spontaneously, without antecedent illness, while the patient was in the Army. A total of 6,650 ml. of thick, milky fluid was removed in the course of a number of thoracenteses. Stains of the material for fat were negative, as were cultures for bacteria, fungi, and tubercle bacilli. Many polymorphonuclear leukocytes were seen in it. A diagnosis of empyema was made, and streptokinase was instilled, after which the patient became febrile. After thoracentesis, the fluid failed to reaccumulate, and the patient was in good health for the subsequent four and one-half years except for mild loss of energy.

Thirteen months prior to his present illness, he noticed an increase in abdominal girth, associated with difficulty in breathing, and with abdominal pain when the fluid accumulation became large. He was hospitalized in a neighboring town Feb. 7 to March 7, 1957, and several paracenteses yielded milky fluid containing fat globules, with 16 mg. % cholesterol in the fluid and negative smears for tumor cells. Barium enema studies and a roentgenogram of the chest were normal. An exploratory celiotomy was performed on Feb. 18, 1957, and no abnormalities were found except for milky ascitic fluid. The portal pressure was within normal limits, and pancreatic biopsy was normal. Omental biopsy showed chronic inflammation with focal areas of fibrosis and calcification, with proliferation of blood vessels and infiltration with lymphocytes. An omental lymph node showed possible lymphatic obstruction, with dilatation of hilar channels and many lipid particles and many mononuclear cells containing lipid. Cortisone was administered and the patient was discharged with the diagnosis of chylous ascites of unknown etiology. In the course of the following seven weeks, abdominal fluid reaccumulated, and he was admitted for a second time to the same hospital, on April 25, 1957, for gastroenteritis, presumably of viral origin, and for removal of more chylous ascitic fluid.

The patient was admitted to the Veterans Administration Hospital in Salt Lake City for the first time on June 6, 1957, for evaluation of his condition. At this time, he had no symptoms and only a small amount of ascitic fluid. Hematocrit was 47%; total protein was 6.9 gm. % and albumin 4.8 gm. %. The tuberculin skin test was negative; the fat content of the chyle was 3 gm. %; unremarkable upper gastrointestinal and barium enema studies were obtained, and laminagraphy of the mediastinum was interpreted as normal. Cortisone was discontinued at that time. In September, 1957, the ascitic fluid began to reaccumulate, and he was sent to a Veterans Administration Hospital in another city for evaluation, from Sept. 23, to Oct. 11, 1957. The report from this hospital was that the ascitic fluid contained true chyle, and the episode of pleural effusion in 1952 was regarded by this group as chylothorax also. Cortisone therapy was resumed in October, 1957, in doses varying between 10 to 40 mg., without benefit.

Physical Examination.—Blood Pressure 140/90; pulse 90 and respirations 26, a minute; temperature: 98 F.

The patient was thin and dyspneic and complained of abdominal pain. The abdomen was distended and showed the usual signs of abdominal fluid, but the liver and spleen were not palpable. The lung fields appeared restricted on percussion, but no rales were audible. On examination of the heart an apical systolic murmur was audible, but no enlargement or arrhythmia was noted. Small nodes were palpable in the left axilla. Urinalysis was negative. The leukocyte count was 11,600 per cubic millimeter on admission with 6% juvenile forms, 76% polymorphonuclear neutrophils, 14% lymphocytes, 3% mononuclear cells, and 1% eosinophils. From Feb. 24 to April 8 serial counts of leukocyte number and lymphocyte percentage, respectively, were 11,600 and 14; 9,500 and 13; 7,300 and 18; 10,800 and 10; 11,100 and 14; 4,600 and 52, and 11,000 and 12.

Course in Hospital.—The patient was placed on a diet of 95 gm. of fat, 101 gm. of protein, and 196 gm. of carbohydrate. After a period of three days his diet was changed to 41 gm. of fat, 157 gm. of protein, and 366 gm. of carbohydrate. After a third paracentesis, he was started on a diet containing 10 gm. of fat, and cortisone was discontinued shortly after he was admitted.

Electrophoresis studies of fluid removed at the time of paracentesis were consistent with the presence of true chyle, and the fatty portion of the chyle showed the presence of neutral fat. The first paracentesis, of 10,150 ml., had a specific gravity of 1.012, an alkaline pH, and a total cell count of 500 per cubic millimeter, of which over 90% were lymphocytes. Chyle obtained at the second paracentesis had a specific gravity of 1.008, with a total cell count of 122, including 59 lymphocytes per cubic millimeter. The fat content was 3 gm. %, and the pH was 7.5. Studies of material from the third paracentesis showed 1.36 gm. % of fat, a specific gravity of 1.010, 59 lymphocytes per cubic millimeter, and a pH of 7.5. Additional determinations were as follows: urea nitrogen, 22 mg. %; chloride, 113 mEq. per liter; sodium, 139 mEq. per liter;

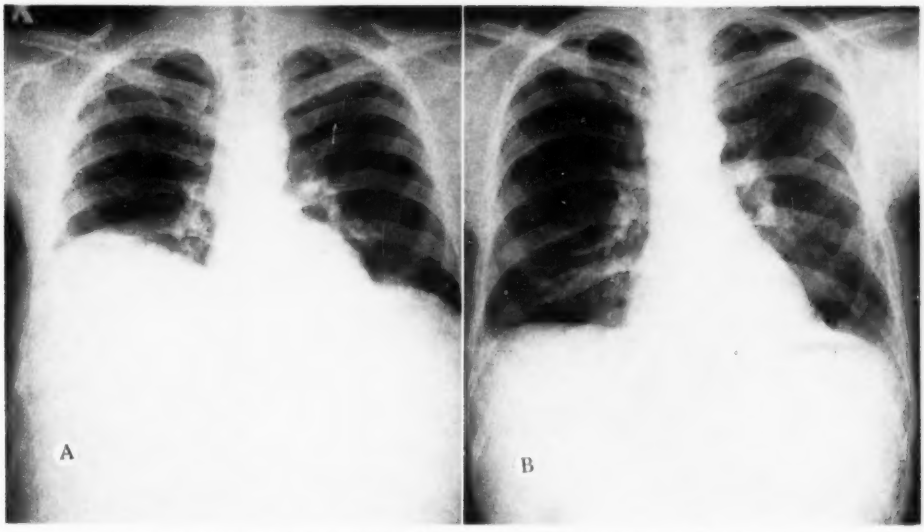


Fig. 1 (Case 1).—*A*, roentgenogram before operation, demonstrating large accumulations of chyle within the abdominal cavity. *B*, postoperative film, showing resolution of chylous extravasation.

cholesterol, 38 mg. %, and total protein, 1.0 gm. %. The patient was transferred to the surgical service for operation on March 17, 1958, but operation was postponed because the patient developed pronounced laryngitis and pharyngitis. On April 3, 5,300 ml. of fluid was withdrawn, and on April 7, 13,400 ml. was withdrawn. On April 9, 1958, an exploratory thoracotomy was performed.

Operation.—Under endotracheal cyclopropane-ether anesthesia, the patient was turned on his right side, and the left thoracic cavity was entered through the eighth interspace. The mediastinum was opened by means of a longitudinal incision in the mediastinal pleura posterior to the pulmonary ligament, exposing the thoracic esophagus and aorta. The dissection was then extended to the celiac axis below the diaphragm. Numerous dilated lymphatic channels were easily identified in the mediastinum, most of them in close proximity to esophagus and aorta. Extending from these channels from a level of 5 cm. above the diaphragm to the celiac axis were numerous diverticula, a number of which were leaking. Dissection upward to the subclavian vessel on the left showed no evidence of obstruction above. Because of the extensiveness of the collateral channels and the obvious source of the leaking chyle, resection of the abnormal lymphatic channels in the area immediately above and below the diaphragm was carried out. A careful search was made before the procedure was concluded, in order not to leave any of the thin-walled vessels. The use of dye or radiopaque material for identification of channels or obstructive points was not necessary, and anastomosis of the lymphatics to the venous system in the chest was thought not indicated because of the existence of collateral channels and the absence of obstruction of the thoracic duct superiorly. Although the source of the ascites was clear, the etiology remained obscure after surgery, and microscopic studies revealed nothing in addition to identifying the tissue removed as lymphatic vessels.

Postoperative Course.—The patient's postoperative course was uneventful. He was treated prophylactically with antibiotics, soon regained his strength, and, to date, one year after his discharge, on May 21, 1958, has had no recurrence of his symptoms and no reaccumulation of fluid either in the chest or in the abdomen (Figs. 1*B* and 2). One month after discharge he resumed his occupation and five months later had gained 20 lb.

CASE 2.—*Chief Complaint.*—The patient, a male infant, was admitted on Feb. 4, 1958, to the care of Dr. Robert Ely, having been referred by Dr. Thales H. Smith, because of edema of the scrotum and lower extremities and abdominal distention.

Present Illness.—The child was born six weeks before admission, following a full-term gestation, complicated by pyelophlebitis during three months of the second trimester. Labor lasted two hours after spontaneous onset. The patient weighed 7 lb. and 11 oz. (3,487 gm.) and breathed without difficulty immediately after birth. His face was edematous, particularly about the right eye, but this cleared after several days. When 5 days old,

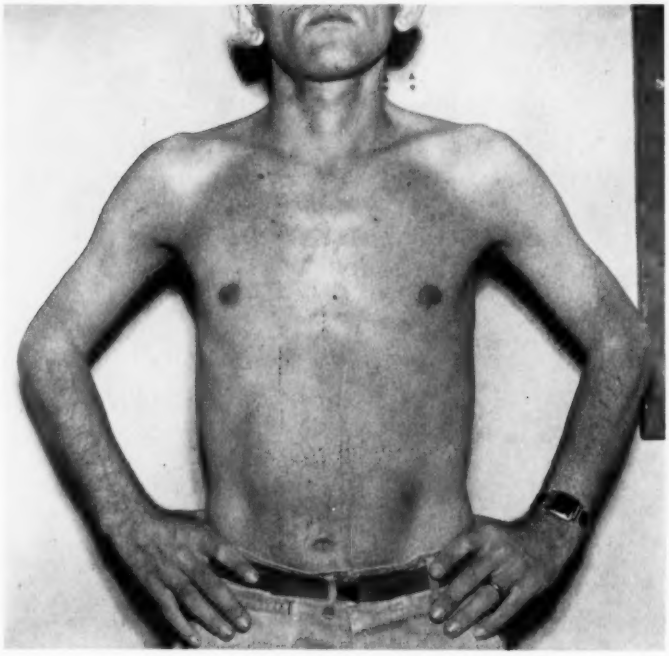


Fig. 2 (Case 1).—Appearance of patient six months after ligation and excision of varices and cysts of the thoracic duct.

he was circumcised, and scrotal edema and swelling of the lower extremities were first noted on the following day. Also, vomiting occurred two to three hours after each feeding, with considerable spitting in between. Diagnostic studies in a neighboring hospital when the patient was 12 days old revealed hypoproteinemia, and, during the five days of hospitalization, γ-globulin and digestine were administered. The edema persisted, and swelling of the abdomen gradually appeared. Vomiting once or twice a day continued until the present admission.

Physical Examination.—Temperature 99 F; pulse 110 and respirations 44, a minute. Weight 8 lb. 14 oz.; height 21.5 in.

The infant appeared chronically ill and undernourished and exhibited massive pitting edema of the scrotum and lower extremities and abdomen. The lungs were clear to percussion and auscultation. Cardiac rhythm was regular; the aortic second sound was greater than the pulmonary second sound, and a Grade 2 systolic murmur was audible at the apex. The abdomen was protuberant, with superficial venous engorgement; but the liver and spleen were not palpable, and the abdomen was not tender. Bilateral inguinal hernia was present. Except for edema, the genitalia were normal.

Laboratory Findings.—Hemoglobin was 13.5 gm. % on admission. This gradually fell to 7.5 gm. % during hospitalization and rose to 12.5 gm. % on discharge, after repeated blood transfusions. The leukocyte count on Feb. 4 was 10,200 and on Feb. 28 was 9,200, per cubic millimeter. The respective lymphocyte percentages on these two dates were 31 and 63. A differential count was not done subsequently. The blood urea nitrogen was 6.5 mg. % on admission, reached 80 mg. during hospitalization, and decreased to 18.5 mg. on discharge. Total serum protein on admission was 3.4 gm. %, with an A/G ratio of 1.0/2.4. On discharge, the A/G ratio was 3.4/1.0. Thymol turbidity was 0.3 unit; alkaline phosphatase was 7.2 units; cephalin flocculation was 3+, and serum cholesterol was 109 mg. %. Duodenal aspiration and stool specimens were positive for trypsin in 1:250 dilution. An electrocardiogram was normal. A roentgenogram of the chest showed possible infiltration of the right upper lung field, but the infiltrate was no longer present when roentgenograms of the chest were repeated. Gastrointestinal roentgenographic studies were reported as negative. Urinalysis was also negative, except for pyuria following catheterization.

Hospital Course.—The possibility of surgery was considered carefully, but a more conservative initial regimen was thought advisable. The patient was placed on a high-caloric intake but low-fat diet, supplemented by parenteral whole-blood transfusion, salt-free albumin, and vitamins. On one

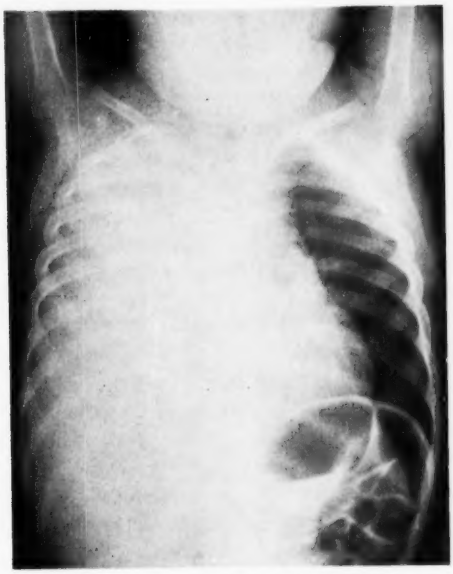


Fig. 3 (Case 3).—Roentgenogram showing extent of chylous extravasation in right thoracic cavity following thrombosis of right and left innominate and left jugular veins.

occasion, the patient inadvertently received an excess of salt-free albumin, resulting in pulmonary edema, which responded to phlebotomy. Paracentesis yielded 60 ml. on Feb. 6; 60 ml. on Feb. 10; 5 ml. on Feb. 14; 150 ml. on Feb. 16; 180 ml. on Feb. 19; 265 ml. on March 3; 200 ml. on March 15, and 280 ml. on March 24. The fat content of the ascitic fluid varied from 200 to 900 mg. %. Specific gravity was 1.007 in most specimens, and the pH was 7.5 or more. As this regimen of repeated paracenteses, transfusions, and the administration of albumin progressed, the patient slowly improved, and, after discharge, on March 29, 1958, only two additional paracenteses were required, in April, 1958. During the interval since this time, the child has had cardiac failure following pulmonary infection on several occasions. The accumulation of abdominal fluid, which presumably does not contain chyle now, has been easily controlled by the use of diuretics. Currently the patient is on a maintenance dose of digitalis.

CASE 3.—*Chief Complaint.*—The patient, a 2-year-old white boy, was first seen on Aug. 22, 1958, a few hours before death, for possible exploration of the left side of the neck because of difficulty in maintaining a functional ventriculojugular shunt, performed for congenital hydrocephalus.

Past History.—The patient was first operated on at 6 months of age, when a right ventriculojugular shunt was performed for congenital hydrocephalus. This became obstructed in March, 1957, and was explored, with change of catheters. On March 17, 1958, he was readmitted because of nausea, vomiting, and lethargy, associated with increased intracranial pressure. A plugged catheter was again found, and pressure symptoms were relieved, despite complicating meningitis. In May, 1958, the parents noted that the fontanel had again become tense, and nausea and vomiting occurred. Swelling of the upper chest, eyes, and face were first noted in June, 1958. Accompanying this were intermittent fever and a slight cough. A cerebrospinal fluid leak was found, and a catheter drain was placed in the ventricular system, allowing decompression for several days. On July 14, this was replaced by left ventriculojugular shunt. Some swelling in the neck on the left occurred after this, although there was no fever, nausea, vomiting, or respiratory obstruction. Following the operation, bulging of the scalp did not diminish as desired, and, after a brief interval, swelling over the neck and chest returned. Consultation was requested because of persistent fluid in the right chest (Fig. 3) and because milky fluid was aspirated from the catheter on the left side during his ninth admission to the hospital.

Physical Examination.—Blood pressure 140/60; pulse 90 and respiration 30, per minute; temperature 99.2 F.

The child responded lethargically to stimulation and was obviously extremely ill. The occipitalfrontal circumference was 52 cm., and the anterior fontanel was 2 cm. in diameter but did not bulge. A peculiar, brawny swelling was seen over the right upper chest and lower neck, and there was shift of the mediastinum to the left, with dullness to percussion over the right hemithorax. A soft systolic murmur was audible at the base of the heart. Nothing unusual was found when the abdomen, genitalia, and extremities were examined. Hemoglobin was 9.5 gm. %, and leukocytes numbered 4,900 per cubic millimeter, with segmented neutrophils 46%, eosinophils 1%, basophils 1%, lymphocytes 48%, and monocytes 4%. Urinalysis was negative.

The impression at this time was that the child was suffering chiefly from the effects of the blocked shunt, despite the collapsed fontanel, and that the thoracic duct had been obstructed due to venous thrombosis, accounting for the right chylothorax.

Hospital Course.—Thoracentesis was advised, with roentgenography to follow. Review of roentgenograms revealed diffuse density throughout the right hemithorax, confirming the findings of physical examination. Thoracentesis was uneventful and yielded 350 ml. of chyle, the albumin content of which was 3.5 gm. %. The patient died two hours later.

Autopsy.—Autopsy showed an occlusive thrombus in the left innominate and jugular veins, partial occlusion with thrombosis of the right innominate vein, focal adhesions and thickening of the leptomeninges, congestion and edema of the right lung, and chylous effusion in the pleural and pericardial cavities. The thrombi had evidently occluded the lymphatic drainage as an added complication of the jugular thrombosis following ventriculojugular anastomosis.

Etiology of Chylous Extravasation

The reason for the extravasation of chyle in a given clinical case varies from the obvious to the obscure. McNab and Scarlett,[109] Brewer,[20] and others have classified the causes of chylothorax, and the general classification illustrated in the Table is a useful

Etiology of Chylous Extravasation

- Trauma
  - Operative
  - Nonoperative
    - Compression and hyperextension
    - Gunshot and stab wounds
    - Fractures
    - Coughing
- Obstruction or infiltration
  - Neoplasia
  - Infection and infestation
    - Granuloma (tuberculosis)
    - Microfilariasis
  - Varix
  - Thrombosis
  - Cirrhosis
  - Intestinal obstruction
- Idiopathic

one for considering all types of the condition. Operative injury of the duct and its radicals is not reported often but occurs occasionally.[48,65,87,156] Loe [99] has emphasized the dangers of injury to the upper portion of the duct in operations such as radical neck dissection and section of the scalenus anticus muscle. The increased number of thoracic operations in recent years has multiplied the chance of injury to the thoracic ducts, but Smithwick [6] minimizes the danger of leak after operative trauma during sympathectomy.[127,130] Nonoperative trauma does not necessarily have to be violent, and Penick [145] suggests that extravasation may be the result of injury to some of the delicate collateral channels. Coughing and attempts at resuscitation in infants may also damage this portion of the lymphatic system. In addition to compression or traction, the ducts may be injured directly by bullets and stab wounds or perforated by fragments of fractured bone. Injuries from accidents with wagons reported in the 19th century have been replaced with similar damage by automobiles in the 20th century. Chylothorax * follows trauma † more frequently than does chylous ascites and may be either unilateral or bilateral [23] and combined with chyloperitoneum ‡ and chylopericardium.[152]

Obstruction and damage to the wall of cisterna chyli and ducts have been reported as a result of intrinsic or extrinsic neoplastic disease,§ infections,[90,125] atherosclerosis,[122] thrombosis,[168] cysts,[15] and infestation. Carcinoma and sarcoma, particularly lymphoma, as well as granulomas,[137] usually from tuberculosis,[19,133,155] are the commoner reasons for this type of the disease. Microfilariasis is, of course, not a problem in this country. Chylous extravasation may be associated with hepatic cirrhosis and intestinal obstruction; and varices of the ductal system, such as the outpouchings encountered in the first case of this report, are apt to leak at the slightest provocation when once established. When chyle is found in the peritoneal cavity, the reason for the leak frequently cannot be determined at operation or autopsy. The third case, consisting of extravasation following thrombosis of veins in the neck, is a clinical example of the effect of thrombosis on chylous extravasation, first demonstrated experimentally.[16,135] Chylothorax will appear in a predictable manner when the superior vena cava is occluded [27] but rarely when the thoracic duct itself is obstructed. More information about the pathogenesis of chylous extravasation [55,64,102,105,164] will doubt-

* References 9, 26, 53, 54, 57, 59, 63, 69, 70, 78, 81-85, 96, 100, 107, 111, 120, 123, 124, 129, 131, 142, 143, 148, 153, 157, 160, 161, 167.

† References 12, 18, 29, 43, 47, 52, 62, 66, 94, 97, 110, 118, 144, 149, 150, 154, 165.

‡ References 17, 77, 103, 136, 146, 158.

§ References 36, 46, 56, 68, 108, 116, 117, 159.

less be forthcoming as operative treatment becomes commoner.

Symptoms

From the standpoint of management, it is far better to consider chylous extravasation as a disease of the thoracic duct system. Nonetheless, from the standpoint of symptomatology, the disease can be divided into distinct groups of cases both as to type and as to the time of onset of symptoms. Early in the disease, the appearance of chyle in the abdominal cavity [71,88,92] may occur in two principal ways. In the first there is painless, cumulative ascites, and most of the symptoms are due to the presence of a large amount of fluid in the abdominal cavity. This type occurs very commonly in infants and children, and, because of the patency of the tunica vaginalis, chylocele may be the first thing noted by the patient or the patient's family. In adults, chyle may also dissect downward and present in the inguen.[20] The chyle may leak in quantities as high as 2 liters per day, and the cumulative amount has reached as high as 500 liters in one patient over a period of 16 months.[115] The other type of case is that in which the patient's presenting symptoms are those characteristic of the acute abdomen. The patient complains of pain, which may become localized and associated with tenderness and rigidity. The presence of fluid may or may not come to the examiner's attention, and nausea may be present. It is frequently confused with appendicitis, and cases have also been reported in which celiotomy was performed with a preoperative diagnosis of cholecystitis, mesenteric embolus, or perforated viscus. The reason for the pain is puzzling, since chyle itself causes no such reaction when introduced into the abdominal or pleural cavities; and the designation of this condition as "chylous peritonitis" is not appropriate, since chyle is known to have bacteriostatic properties [166] and infection of pleural and abdominal cavities is rare in most cases, despite repeated taps.

When damage to the thoracic duct occurs, there is often a characteristic interval without symptoms, possibly due to failure of the examiner to detect the fluid at first, or, more likely, to the time required for the chyle to break through the pleura or peritoneum into the thoracic or abdominal cavity. When this occurs in the chest, it may be accompanied by dyspnea and a shock-like state, which is relieved by removing the fluid. Injury to the duct in the neck may result in a fistula, which calls attention to the condition, or swelling may be present in a closed wound. The appearance of ascites may be accompanied by antecedent swelling and pain in the neck and a transitory thrill. Late symptoms of the disease are the result of the loss of chyle and failure of the thoracic duct to function as the pathway for mobilization of proteins and the transport of fats to the venous circulation. This phase of the disease is characterized by loss of weight, hypoproteinemia, inanition, oliguria, apathy, and, if not corrected, death.

Diagnosis

The diagnosis of chylous extravasation is usually made by examination of fluid withdrawn from the peritoneal and thoracic cavities or obtained from a cervical fistula or collection. Confirmation is obtained on microscopic examination when material is stained with lipophilic stain. Wyatt and Gross [169] noted that the chylous ascitic fluid in an infant was more radiolucent than the adjacent liver, thus differentiating it from other types of ascitic fluids. However, Lowman et al.[101] do not find any roentgenographic differentiation between chylous and other fluid in the chest.[134] Routine postoperative roentgenograms may be helpful in detecting fluid early when injury of the thoracic duct system is suspected at the time of surgery. Lateral and oblique views, as well as those taken in the lateral recumbent position, and fluoroscopy may be helpful in detecting collections of fluid in the chest which otherwise would be obscure.

The cellular component of chyle consists almost exclusively of lymphocytes which Bierman et al.[14] found to number from 210 to 5,600 per cubic millimeter in thoracic-duct lymph. Others have described up to 20,000 per cubic millimeter. One would suspect that extravasation of large amounts of chyle would lead to a decrease of lymphocyte count in the peripheral blood. However, this has not been particularly helpful as a diagnostic tool, possibly because it has not been used extensively in clinical practice. In comparing the constituents of chyle and blood,[25,45,51,74] it is always better to take samples of the two simultaneously, rather than to obtain absolute values. When this is done, the electrolyte content of chyle is approximately the same as that for plasma, with few exceptions. The cholesterol content may be higher and the albumin and globulin content lower than corresponding values for blood. Also the platelet count is lower than that of venous blood, varying from 1,000 to 100,000 per cubic millimeter. Wallis and Schölberg[163] believe that when the specific gravity is below 1.012, the material represents a pseudoeffusion. Usually the specific gravity of chyle varies from 1.010 to 1.021 and the pH is alkaline. On standing, chyle is stratified into three layers. There is an upper creamy layer, an inconstant dividing watery layer, and a lower colorless and opaque layer. Vitamins A and D may be lost in the chyle, and Forbes[60] has advised the administration of aqueous preparations in cases of chylous extravasation in order to promote the entrance of the material into the venous circulation through other routes because of the smaller particle size. Clotting does not ordinarily occur because of the excess of antithrombin and low content of thromboplastin. Freeman and Johnson[61,86] believe that a hemolytic agent is present in chyle and possibly is not present in other lymph.

One of the most troublesome problems in treatment is localizing the source of the leakage of chyle. Merrill[113] recommends the subcutaneous injection of Evans blue dye (T 1824) in order to outline the thoracic duct system at the time of surgery. Also, the tributaries of the thoracic duct are both dilated and stained when cream or butter stained with scarlet red, Sudan III, or some other suitable lipophilic stain is fed before operation. Injection of radiopaque material may be useful in delineating the duct system and collaterals, as well as the point of leakage at operation, but retrograde flow may not be satisfactory for this purpose because of the presence of valves in the system.

Treatment

Sabin[138-141] and others[5,37,106] have carefully observed and recorded the development of the lymphatic collecting channels. The cisterna chyli may be seen opposite the third and fourth vertebrae in the 23-mm. stage in man, and the thoracic duct appears at the 24-mm. stage. Careful dissections of the thoracic duct led Davis[39] to propose an anatomical classification, with nine types of arrangements, depending on the pattern in which the bilateral ducts and anastomosis persist in the adult. Subsequent roentgenographic studies[28,112,147] have confirmed the wide variation in distribution of this collecting system. Terminations of the ducts[126] may empty into the angulus venosus; the innominate, internal jugular and vertebral veins, or the subclavian veins. Knowledge of function || and these variations in the anatomy[22,73,128,162] of the thoracic duct system and collateral channels[95,114] is essential for a logical approach to therapy.

Treatment[75,79] of chylous extravasation may be expectant, definitive, or supportive; and, as in making the diagnosis, the disease must be considered one involving a single system, although it may be affected at any locus throughout its distribution. This view is particularly applicable to the problem concerning the location of the incision when operation is indicated. The decision is usually straightforward in cervical[22] extravasations, but a thoracic exploration may be

|| References 1, 10, 13, 30, 34, 38, 49, 50, 72, 76, 89, 91, 104, 119, 151.

more profitable than celiotomy in cases of ascites. In the case of chylous ascites,[21] there are numerous cases in which the condition has subsided after one to many paracenteses. The reason for the recovery is not always clear, but the advisability of delay is questionable when nutritional problems appear, due to the prodigious loss of chyle. One is deterred somewhat, however, by the knowledge that such explorations may reveal neither the source of the leak nor the etiology of the disease, as well as fail to afford an opportunity for additional therapy.

In cases with presenting symptoms of the acute abdomen, operation is the only choice if the results of paracentesis are negative. When operation is done and the source of the leak is found, excision of this portion of the system or ligation suffices. On rare occasions it may be wise to marsupialize a cyst containing chyle, but convalescence is usually prolonged subsequently. Release of intestinal obstruction may be followed by cessation of the accumulation of chyle, and simple excision of mesenteric cysts and angiomas containing chyle may suffice as well. Surgical removal of tumors causing obstruction, with the exception of lymphomas, is the treatment of choice. Granulomas,[11] particularly those of tuberculosis,[3] may present a difficult problem, and a makeshift repair of the opening, using omentum and plication, may be required, rather than resection or ligation. Radiation therapy is not indicated in treating chylous effusion except when it occurs with lymphomas.

The prompt replacement of fluid, protein, fats, and vitamins A and D lost in the chyle prevents development of the late sequelae, which so often have been fatal in the past. Although restriction of fat in the diet may reduce the amount of fat lost in the chyle, there is some doubt as to whether restriction of proteins and fluids alters the chyle in any consistent manner. Fat emulsions have not been available for a sufficient period of time to determine their usefulness in this type of case, but they offer an additional means of treatment where indicated.[80] Results in recent years suggest that supportive therapy can maintain the patient in good condition during the relatively short period in which withdrawal of chyle is given a trial.

Anastomosis of the thoracic duct system to veins has been endorsed by Deansley,[40] Harrison,[75] Hodge and Bridges,[79] De Marchi,[42] and Brewer,[20] and peritoneal-venous operations and the Talma operation have been tried for chylous extravasation in the past, with indifferent success. The low flow rate and differential pressure, small size of the lumen, poor results in obtaining patent venous anastomosis of similar size, lack of objective evidence from late results, and the possibility that the correction of chylous extravasation may not be due to a functioning anastomosis suggest caution in accepting this as an advisable procedure except in otherwise hopeless situations, even though the objective of reestablishing a large vent into the venous system seems laudable. Pneumothorax, phrenemphraxis,[121] the installation of broth and chloroazodin (Azochloramid) for the promotion of fibrinous reaction, and oral or intravenous or intrasternal administration of chyle offer nothing or have been supplemented by more effective management. The administration of chyle[8,98,127,144] has been associated with death,[166] although the reason for this outcome has not been clear. In general, the tendency to perform exploratory thoracotomy early,[33] and not to prolong the trial of paracentesis before resorting to celiotomy, promises to improve the mortality rate in cases of chylous extravasation. Care to avoid injury during operation and to be alert to repair damage[35] when it occurs also deserves emphasis.

Summary

Although known for over 300 years as a clinical entity, the treatment of chylous extravasation has been promising only recently.

Management is most effective when the following principles are observed.

1. The condition is regarded as one involving a single system, the clinical manifestations depending on the locus affected.

2. Conservative management by withdrawal of chyle is limited unless improvement occurs promptly.

3. Surgery is performed early and consists of ligation or excision of the affected portion of the system.

4. Visualization of the ductal system is carried out through the use of lipophilic dyes or angiograms when a question of adequate collateral drainage arises.

5. Supportive treatment is adequate to repair the fluid and nutritional deficit resulting from the leakage of chyle.

6. The surgeon is vigilant both to avoid operative injury to the thoracic duct and to recognize and repair it at the time it occurs.

Three personal cases of chylous extravasation are presented from a hospital population, in which the incidence is 1 in 56,343 admissions.

Department of Surgery, University of Utah College of Medicine.

REFERENCES

1. Acevedo, D.: Motor Control of Thoracic Duct, Am. J. Physiol. 139:600, 1943.

2. Allen, D. P., and Briggs, C. E.: Wounds of the Thoracic Duct Occurring in the Neck: Report of 2 Cases; Résumé of 17 Cases, Am. Med. 2: 401, 444, 1901.

3. Ameuille, P., and Perreau, P.: Thrombose tuberculeuse du canal thoracique, Bull. et mén. Soc med. hôp. Paris 49:1234, 1933.

4. Asellius, G.: De lactibus, sive lacteis venis, quarto vasorum mesaraicorum genere, novo invento, dissertation, Milan, 1627.

5. Baetjer, W. A.: On the Origin of the Mesenteric Sac and Thoracic Duct in the Embryo Pig, Am. J. Anat. 8:303, 1908-1909.

6. Baldridge, R. R., and Lewis, R. V.: Traumatic Chylothorax: Review of Literature and Report of Case Treated by Ligation of Thoracic Duct and Cisterna Chyli, Ann. Surg. 128:1056, 1948.

7. Bargebuhr, A.: Chylöse und chyliforme Ergüsse in Pleura- und Pericardialraum, Deutsches Arch. klin. Med. 56:410, 1894-1895.

8. Bauersfeld, E. H.: Traumatic Chylothorax from Ruptured Thoracic Duct Treated by Intravenous Injection of Aspirated Chyle, J. A. M. A. 109:16, 1937.

9. Beatty, O. A.: Chylothorax: Case Report, J. Thoracic Surg. 6:221, 1936.

10. Beck, C. S.: Study of Lymph Pressure, Bull. Johns Hopkins Hosp. 35:206, 1924.

11. Benda, C.: Lymphogranulomatose des Ductus thoracicus, Centralbl. allg. Path. u. path. Anat. 37:544, 1926.

12. Berry, W. H.: Traumatic Chylothorax Resulting from Battle Injury, J. A. M. A. 133:319, 1947.

13. Biedl, A., and von Decastello, A.: Über Änderungen des Blutbildes nach Unterbrechung des Lymphzuflusses, Arch. ges. Physiol. 86:259, 1901.

14. Bierman, H. R.; Byron, R. L., Jr.; Kelly, K. H.; Gilfillan, R. S.; White, L. P.; Freeman, N. E., and Petrakis, N. L.: The Characteristics of Thoracic Duct Lymph in Man, J. Clin. Invest. 32:637, 1953.

15. Biggar, H. F., Jr.: A Case of Chylous Cyst of the Thoracic Duct, Cleveland M. J. 6:196, 1907.

16. Blalock, A.; Cunningham, R. S., and Robinson, C. S.: Experimental Production of Chylothorax by Occlusion of Superior Vena Cava, Ann. Surg. 104:359, 1936.

17. Blood, M. J., and Fairchild, R. C.: Two Cases of Chylous Ascites and Chylothorax in Infants with Recovery, J. Kansas M. Soc. 54: 108, 1953.

18. Boegehold, E.: Über die Verletzungen des Ductus thoracicus, Arch. klin. Chir. 29:443, 1883.

19. Brandt, M.: Ein Beitrag zur Kasuistik der Ductus-thoracicus-Tuberkulose und des Chylothorax, Heidelberg, J. Hörning, 1917.

20. Brewer, L. A., III: Surgical Management of Lesions of the Thoracic Duct, Am. J. Surg. 90:210, 1955.

21. Brescia, M. A.: Chylothorax: Report of a Case in Infant, Arch. Pediat. 58:345, 1941.

22. Brinton, J. H.: Surgical Relations of Thoracic Duct in Neck, Tr. Philadelphia Acad. Surg. 20:86, 1894; Coll. & Clin. Rec. 15:114, 1894.

23. Brown, A. L.: Traumatic Rupture of Thoracic Duct with Bilateral Chylothorax in Chylous Ascites, Arch. Surg. 34:120, 1937.

24. Busey, S. G.: Effusion of Chyle and of Chyle-like, Milky, Fatty, Oily Fluids into Serous Cavities, Am. J. M. Sc. 98:563, 1889.

25. Cain, J. C.; Grindlay, J. H.; Bollman, J. L.; Flock, E. V., and Mann, F. C.: Lymph from Liver and Thoracic Duct, Surg. Gynec. & Obst. 85:559, 1947.

26. Campbell, D. G. J.: A Case of Chylothorax, Maritime M. News 18:295, 1906.

27. Carlson, H. A.: Obstruction of the Superior Vena Cava: An Experimental Study, Arch. Surg. 29:669, 1934.

28. Celis, A., and Porter, J. K.: Lymphatics of the Thorax: An Anatomic and Radiologic Study; Preliminary Report, Acta radiol. 38:461, 1952.

29. Cellan-Jones, C. J., and Murphy, W.: Traumatic Chylothorax, Brit. M. J. 2:590, 1940.

30. Co Tui; Barcham, I., and Shafiroff, B. G. P.: Ligation of the Thoracic Duct and the Posthemorrhage Plasma Protein Level, Surg. Gynec. & Obst. 79:37, 1944.

31. Cooper, A. P.: Three Instances of Obstruction of the Thoracic Duct, with Some Experiments, Showing the Effects of Tying That Vessel, M. Rec. Private M. A., London, p. 86, 1798.

32. Cowie, D. M.: The Casuistry of Chylous Ascites and Chylocele in Sucklings and Very Young Infants: Report of a Case, Arch. Pediat. 28:595, 1911.

33. Crafoord, C.: A Contribution to Thoracic Duct Surgery, Acta chir. scandinav. 85:99, 1941.

34. Crandall, L. A., Jr.; Barker, S. D., and Graham, D. G.: Study of Lymph Flow from a Patient with Thoracic Duct Fistula, Gastroenerology 1:1040, 1943.

35. Cushing, H.: Operative Wounds of the Thoracic Duct: Report of Case with Suture of the Duct, Ann. Surg. 27:719, 1898.

36. Creyx and Gauvenet: Cancer secondaire du canal thoracique, J. méd. Bordeaux 42:812, 1912.

37. Cunningham, R. S.: On the Development of the Lymphatics of the Lungs in the Embryo Pig, Contrib. Embryol. 4:47, 1916.

38. Davis, B. F., and Carlson, A. J.: Contribution to the Physiology of the Lymph. IX. Notes on the Leucocytes in the Neck Lymph, Thoracic Lymph, and Blood of Normal Dogs, Am. J. Physiol. 25:173, 1909.

39. Davis, H. K.: A Statistical Study of the Thoracic Duct in Man, Am. J. Anat. 17:211, 1914-1915.

40. Deansley, E.: Case of Implantation of Divided Thoracic Duct into Internal Jugular Vein: Recovery, Lancet 2:1783, 1903.

41. De Forest, H. P.: Surgery of Thoracic Duct, Ann. Surg. 46:705, 1907.

42. De Marchi, C.; Mondini, P., and Gamla, A.: Modern Conception of Surgery of the Thoracic Duct: Experimental Study, Chirurgia italiana 81: 6, 1951.

43. Derganz, F.: Chylothorax Traumaticus, Wien. klin. Wchnschr. 28:1320, 1915.

44. de Diemerbroeck, I.: Opera omnia anatomica et medica, Ultraj, M. a Dreunen et G. a Walcheren, 1685.

45. Dittebrandt, M.; Todd, W. R., and West, E. S.: Composition of Chyle from a Case of Traumatic Chylothorax, Arch. Biochem. 2:429, 1943.

46. Dock, G.: Chylous Ascites and Chylous Pleurisy, in a Case of Lymphocytoma Involving the Thoracic Duct, Tr. A. Am. Physicians 22:464, 1907.

47. Dorsey, J. F., and Morris, G. E.: Traumatic Rupture of the Thoracic Duct with Chylothorax: A Brief Review of the Literature, J. A. M. A. 119: 337, 1942.

48. Douaday, D.; Dupuy, D., and Bouvrain, Y.: Chylothorax bénin après section d'adhérences pleurales, Arch. méd.-chir. l'app. respir. 13:284, 1938.

49. Drinker, C. K., and Field, M. E.: Lymphatics, Lymph and Tissue Fluid, Baltimore, Williams & Wilkins Company, 1933.

50. Drinker, C. K., and Yoffey, J. M.: The Lymphatics, Lymph, and Lymphoid Tissue: Their Physiological and Clinical Significance, Cambridge, Mass., Harvard University Press, 1941.

51. Ehrenhaft, J. L., and Meyers, R.: Blood Fat Levels Following Supradiaphragmatic Ligation of Thoracic Duct, Ann. Surg. 128:38, 1948.

52. Elliott, T. R., and Henry, H.: Chylohæmothorax from Wounds Involving Thoracic Duct, Lancet 1:872, 1917.

53. Engstad, J. E.: Chylothorax, Journal-Lancet 46:380, 1926.

54. Everhart, J. K., and Jacobs, A. H.: Chylothorax: A Review of the Literature and Report of a Case in a Newborn Infant, J. Pediat. 15:558, 1939.

55. Fehr, A.: Zur Kenntnis der Verödung des Ductus thoracicus, Arch. path. Anat. 279:265, 1930.

56. Fellner, B.: Fall von Chylothorax bei Leukosarkom, Mitt. Gesellsch. inn. Med., Wien. 6:179, 1907.

57. Felts, R. L.: Chylothorax, with Report of a Case, South. M. & Surg. 89:168, 1927.

58. Florer, R., and Ochsner, A.: Traumatic Chylothorax: Report of Fatal Case, Complicated by Ruptured Duodenal Ulcer, Surgery 17:622, 1945.

59. Foley, G.: Sobre un caso de pleuresia quilosa, Prensa med. argent. 20:62, 1933.

60. Forbes, G. B.: Chylothorax in Infancy: Observations on Absorption of Vitamins A and D and on Intravenous Replacement of Aspirated Chyle, J. Pediat. 25:191, 1944.

61. Freeman, L. W., and Johnson, V.: Hemolytic Action of Chyle, Am. J. Physiol. 130:723, 1940.

62. Fujita, K.; Bando, T., and Sugishita, J.: Ein Fall von Chylothorax traumaticus, Arch. jap. Chir. 16:236, 1939.

63. Fürth, E.: Ein Fall von spontan entstandenen Chylothorax im Kindesalter, Wien. klin. Wchnschr. 40:350, 1927.

64. Gandin, S.: Pathogenese und Klassifikation der Milchartigen Ergüsse, Ergebn. inn. Med. u. Kinderh. 12:218, 1913.

65. Garamella, J. J.: Chylothorax Complicating Cardiac Bypass and Studies in Thoracic Ductography, Minnesota Med. 40:625, 1957.

66. Gordon, J.: Traumatic Chylothorax, Ann. Int. Med. 13:1998, 1940.

67. Gribetz, D., and Kanof, A.: Chylous Ascites in Infancy, with Report of Case with Vitamin A Absorption Studies, Pediatrics 7:632, 1951.

68. Gralka, R.: Über Chylothorax im Kindesalter im Gefolge einer Hodgkin' schen Krankheit, Fortschr. Med. 40:242, 1922.

69. Gullbring, A.: Ett fal av chylothorax, Hygiea 80:840, 1918.

70. Günder, R.: Ein Fall von Chylothorax, München, Kastner and Callwery, 1913.

71. Hall, W. S., and Morgan, W. E.: Case of Chylous Ascites, Quart. Bull. Northwestern Univ. M. School 2:44, 1900.

72. Haller, A.: Elementa physiologiæ corporis humani, Vol. 8, Berne, 1746; Disputationes anatomicæ selectæ, Vol. 1, Gottingæ, A. Vandenhoeck, 1752.

73. Halsted, W. S.: Congenital Arterio-Venous and Lymphatico-Venous Fistulæ: Unique Clinical and Experimental Observations, Contrib. M. & Biol. Res. 1:560, 1919; Proc. Nat. Acad. Sc. 5:76, 1919.

74. Harrell, G. T.; Street, D. M., and Reiser, R.: Chylothorax and Chylous Ascites: Report of Case with Lipid Analyses, J. Lab. & Clin. Med. 24:1045, 1939.

75. Harrison, E.: On Treatment of Wounds of Thoracic Duct, Brit. J. Surg. 4:304, 1916.

76. Heidenhain, R.: Versuche und Fragen zur Lehre von der Lymphbildung, Arch. ges. Physiol. 49:209 1891.

77. Heppner, G. J.: Bilateral Chylothorax and Chyloperitoneum, J. A. M. A. 102:1294, 1934.

78. Hilgenberg, F. C.: Ein Fall von Chylothorax beim Neugeboren, Monatsschr. Geburtsh. u. Gynäk. 83:225, 1929.

79. Hodge, G. B., and Bridges, H.: Surgical Management of Thoracic Duct Injuries, Surgery 24:805, 1948.

80. Holt, L. E., Jr.; Tidwell, H. C., and Scott, T. F. M.: Intravenous Administration of Fat: Practical Therapeutic Procedure, J. Pediat. 6:151, 1935.

81. Hoyer, A.: Chylotoraks, Nord. med. tidskr. 9:40, 1941.

82. Hüssy, A.: Über Chylothorax im Kindersalter, Jahrb. Kinderh. 37:491, 1918.

83. Hyde, F. C.: A Case of Chylothorax, Yale M. J. 16:167, 1909-1910.

84. Jahsman, W. E.: Chylothorax: A Brief Review of the Literature; Report of 3 Non-Traumatic Cases, Ann. Int. Med. 21:669, 1944.

85. Jennings, C. G., and Rich, H. M.: Report of Case of Chylothorax in a Child, Tr. Am. Pediat. Soc. 19:190, 1907; Arch. Pediat. 25:195, 1908.

86. Johnson, V., and Freeman, W.: Adaptive Value of Absorption of Fats into Lymphatics, Am. J. Physiol. 124:466, 1938.

87. Keen, W. W.: Operation Wounds of Thoracic Duct in Neck, Ann. Surg. 20:89, 1894.

88. Kessel, I.: Chylous Ascites in Infancy, Arch. Dis. Childhood 27:79, 1952.

89. Khlopin, N.: On the Influence of Ligating the Thoracic Duct in Dogs upon the Assimilation of Fats, St. Petersburg, A. Muchnitz, 1892.

90. Kryloff, E.: Zur Frage der eitrigen Entzündung des Ductus thoracicus, Arch. path. Anat. 266:1, 1927.

91. Kufferath: Über die Abwesenheit der Gallensäuren im Blute nach dem Verschluss des Gallen- und des Milchbrustganges, Arch. J. Physiol., p. 92, 1880.

92. Laing, C. R., and Scott, R. B.: Chylous Ascites: Report of Case with Recovery and Survival After 14 Years, J. Pediat. 44:191, 1954.

93. Lammers, V.: Zur Kasuistik des nichttraumatischen Chylothorax, Borna-Leipzig, R. Noske, 1910.

94. Lampson, R. S.: Traumatic Chylothorax: A Review of the Literature and Report of a Case Treated by Mediastinal Ligation of the Thoracic Duct, J. Thoracic Surg. 17:778, 1948.

95. Lee, F. C.: Establishment of Collateral Circulation Following Ligation of the Thoracic Duct, Bull. Johns Hopkins Hosp. 33:21, 1922.

96. Lewin, P.: Chylothorax: Case Report, Am. J. M. Sc. 152:71, 1916.

97. Lillie, O. R., and Fox, G. W.: Traumatic Intrathoracic Rupture of Thoracic Duct with Chylothorax, Ann. Surg. 101:1367, 1935.

98. Little, J. M.; Harrison, C., and Blalock, A.: Chylothorax and Chyloperitoneum: Effect of Reintroduction of Aspirated Chyle, Surgery 11:392, 1942.

99. Loe, R. H.: Injuries of the Thoracic Duct: Report of a Case of Chylothorax in Which the Patient Recovered After Ligation of the Thoracic Duct, Arch. Surg. 53:448, 1946.

100. Lotheissen: Uber Chylothorax, Wien. klin. Rundschau 21:5, 1907.

101. Lowman, R. M.; Hoogerhyde, J.; Waters, L. L., and Grant, C.: Traumatic Chylothorax: Roentgen Aspects of This Problem, Am. J. Roentgenol. 65:529, 1951.

102. Lucibelli, C.: Sugli effetti dellallacciatura del condotto toracici, Nouva riv. clin.-terap., Napoli 5:401, 458, 1902.

103. Lyter, J. C.: Chylous Ascites and Chylothorax, M. Clin. North America 11:479, 1927.

104. MacCallum, W. G.: Die Beziehung der Lymphgefässe zum Bindegewebe, Arch. Anat. u. Entwecklngsgeseh., p. 273, 1902.

105. Mayer, in Nockher, F.: De morbis ductus thoracici, Bonn, C. Georgii, p. 35, 1831.

106. McClure, C. F. W.: The Development of the Thoracic and Right Lymphatic Ducts in the Domestic Cat (Felis Domestica), Anat. Anz. 32: 534, 1908.

107. McGregor, H. L.: Injuries to Large Lymph Ducts, Brit. J. Surg. 40:569, 1953.

108. McFarland, J.: A Fibrous Tumor of the Receptaculum Chyli, Tr. Path. Soc. 17:204, 1893.

109. McNab, D. S., and Scarlett, E. P.: Traumatic Chylothorax Due to Intrathoracic Rupture of Thoracic Duct, Canad. M. A. J. 27:29, 1932.

110. Matson, R. C., and Stacy, J. W.: Traumatic Chylothorax: Case Report and New Suggestion for Treatment, Dis. Chest 6:332, 1940.

111. Meade, R. H., Jr.; Head, J. R., and Moen, C. W.: Management of Chylothorax, J. Thoracic Surg. 19:709, 1950.

112. Menkes, B.: Röntgendarstellung der Blut- und Lymphgefässe an der Leiche und am Lebenden mittels Umbrathor und Thorotrast, Fortschr. Geb. Röntgenstrahlen 46:571, 1932.

113. Merrill, K., Jr.: The Use of Evans Blue to Outline the Course of the Thoracic Duct, J. Thoracic Surg. 29:555, 1955.

114. Meyer, A. W.: An Experimental Study on the Recurrence of Lymphatic Glands and the Regeneration of Lymphatic Vessels in the Dog, Bull. Johns Hopkins Hosp. 17:185, 1906.

115. Milton, J. P.: A Case of Chylothorax, with a Record Quantity of Fluid Withdrawn from Left Pleural Cavity, and Ultimate Recovery, Brit. M. J. 2:1210, 1907.

116. Minazziantz, Y.: Un cas de suppuration du canal thoracique et d'adéno-phlegmon sus-claviculaire consécutif à un cancer du pylore, Thesis, Paris, 1927.

117. de Sanctis Monaldi, T.: Carcinomatosi secondaria del dotto toracico, Riforma med. 49: 1284, 1933.

118. Mouchet, A.: Le chylothorax traumatique, J. chir. 42:386, 1933.

119. Munk, I., and Friedenthal, H.: Über die Resorption der Nahrungsfette und den wechselnden Fettgehalt des Blutes nach Unterbindung des Ductus thoracicus, Centralbl. Physiol. 15:297, 1901.

120. Neuenkirchen: Ein Fall von Chylothorax, St. Petersb. med. Wchnschr. 7:459, 1890.

121. Nowak, S. J. G., and Barton, P. N.: Chylothorax: Report of Case Arrested by Phrenicotomy, J. Thoracic Surg. 10:628, 1941.

122. Oberndorfer, S.: Atherosklerose des Ductus thoracicus, Verhandl. deutsch. path. Gesellsch. 20: 247, 1925.

123. Oeken, H.: Ein Fall von Zerreissung des Ductus thoracicus infolge Brustquetschung, München. med. Wchnschr, 55:1182, 1908.

124. Olsen, A. M., and Wilson, G. T.: Chylothorax, J. Thoracic Surg. 13:53, 1944.

125. Pappenheimer, P.: Über eitrige Entzündung des Ductus thoracicus, Arch. path. Anat. 231:274, 1921.

126. Parsons, F. G., and Sargent, P. W. G.: On Termination of Thoracic Duct, Lancet 1:1173, 1909.

127. Peet, M. M., and Campbell, K. N.: Massive Chylothorax Following Splanchnicectomy: Treatment with Intravenous and Intrasternal Transfusions of Chyle, Univ. Hosp. Bull., Ann Arbor 9:2, 1943.

128. Pensa, A.: Studio sulla morfologia e sulla topografia della cisterna chili e del ductus thoracicus nell'uomo ed in altri mammiferi, Ricerche anat. norm. Univ. Roma 14:109, 1908.

129. Pisek, G. R.: Report of a Case of Chylothorax, Tr. Am. Pediat. Soc. 29:144, 1917; Arch. Pediat. 34:929, 1917.

130. Poppen, J. L.: Extensive Combined Thoracolumbar Sympathectomy in Hypertension, Surg. Gynec. & Obst. 84:1117, 1947.

131. Port, K.: Ein Fall von Chylothorax: Casuistischer Beitrag zur Lehre von den Verletzungen des Ductus thoracicus, Deutsche Ztschr. Chir. 39:572, 1894.

132. Quincke, H.: Chylusergass in serose Höhlen hydrops chylosus, Deutsche Arch. klin. Med. 16: 121, 1875.

133. Remé, G.: Doppelseitiger Chylothorax und Spontanpneumothorax bie einem 3 jährigen tuberkulösen Kinde, Monatsschr. Kinderh. 34:135, 1926.

134. Rigler, L. G.: Roentgenologic Observations on Movement of Pleural Effusions, Am. J. Roentgenol. 25:220, 1931.

135. Robinson, C. S.; Cunningham, R. S.; Blalock, A.; Gray, M. E., and Rogers, B. C.: Chylous Effusions Produced by Experimental Ligation of Superior Vena Cava: Chemical and Cytologic Studies, Arch. Path. 24:303, 1937.

136. Rotmann: Über fetthaltige Ergüsse im den grossen serösen Höhlen, Ztschr. klin. Med. 31:416, 1896-1897.

137. Ruddell, K. R.: Chylous Ascites and Chylothorax Due to Lymphogranulomatosis of the Mesentery and the Receptaculum Chyli, Indianapolis M. J. 30:213, 1927.

138. Sabin, F. R.: Lymphatic System in Human Embryos, with Consideration of Morphology of System as a Whole, Am. J. Anat. 9:43, 1909.

139. Sabin, F. R.: Development of the Lymphatic System, in Bardeen, C. R., and Evans, H. M.: Manual of Human Embryology, edited by F. Keibel and F. P. Moll, 1912, Vol. 2, p. 734.

140. Sabin, F. R.: Der Ursprung und die Entwickelung des Lymphgefässsystems, Ergebn. Anat. u. Entwcklngsgesch. 21:1, 1913.

141. Sabin, F. R.: On the Origin of the Lymphatic System from the Veins and the Development

of the Lymph Hearts and Thoracic Duct in the Pig, Am. J. Anat. 1:367, 1902.

142. Sale, L.: Chylothorax: Report of a Case, Interstate M. J. 19:50, 1912.

143. Schaefer, R.: Beiträge zur Kenntnis des Chylothorax, Deutsches Arch. klin. Med. 157:69, 1927.

144. Schnug, E., and Ransohoff, J. Traumatic Chylothorax—Case Treated with Intravenous Chyle, Surgery 14:278, 1943.

145. Shackelford, R. T., and Fisher, A. M.: Traumatic Chylothorax, South. M. J. 31:766, 1938.

146. Shaw, H. B.: Milky Effusions Occurring in Serous Cavities, with Report of a Case of Chylous Ascites and Chylous Hydrothorax, J. Path. & Bact. 6:339, 1899-1900.

147. Shdanow, D. A.: Röntgenologische Untersuchungsmethoden des Lymphgefässsystems des Menschen und der Tiere, Fortschr. Geb. Röntgenstrahlen 46:680, 1932.

148. Sherman, De W. H.: Chylothorax in Children, Arch. Pediat. 24:646, 1907.

149. Shumacker, H. B., Jr., and Moore, T. C.: Surgical Management of Traumatic Chylothorax, Surg. Gynec. & Obst. 93:46, 1951.

150. Smith, D. D., and Woliver, E.: Traumatic Chylothorax, Arch. Surg. 43:627, 1941.

151. Starling, E. H.: Influence of Mechanical Factors on Lymph Production, J. Physiol. 16:224, 1894.

152. Steiner, P.: Chylothorax duplex, Chylopericardium und Ascites chylosus bei einem Fall von fibröser Pleuritis und ausgedehnter Fibrose beider Lungen, Beitr. Klin. Tuberk. 81:757, 1932.

153. Stewart, C. A., and Linner, H. P.: Chylothorax in the New-Born Infant: Report of a Case, Am. J. Dis. Child. 31:654, 1926.

154. Strauss, A.: Chylothorax Due to Bullet Wound of Thoracic Duct and Syndrome of Traumatic Chylothorax: Report of Case, and 7 Cases from Literature, J. Thoracic Surg. 5:539, 1936.

155. Strauss, H.: Über Chylothorax tuberculosus nebst Beiträgen zur chemisch-Mikroskopischen Diagnostik pathologischer Ergüsse, Charite-Ann. 26:89, 1920.

156. Stuart, W. J.: Operative Injuries of Thoracic Duct in Neck, Edinburgh M. J. 22:301, 1907.

157. Syers, H. W.: A Case of Chylo-Thorax, Clin. J., London 16:278, 1900.

158. Temkin, S.: Zur Frage über die Verletzungen des Milchburstganges (Ductus thoracicus) und die Fälle von Chylothorax und Ascites chylosa im Zusammenhang mit dem anatomischen und experimentellen Angaben über das Chylusgefässsystem, Berlin, G. Schade, 1909.

159. Touroff, A. S. W., and Seley, G. P.: Chronic Chylothorax Associated with Hygroma of the Mediastinum, J. Thoracic Surg. 26:318, 1953.

160. Van Nuys, R. G.: Chylothorax, California & West. Med. 34:269, 1931.

161. Veiel, S.: Case of Chylothorax, Deutsche med. Wchnschr. 32:1359, 1906.

162. Vitlin, I.: Injuries to the Thoracic Duct in Cases of Chylothorax and Chylous Ascites in Connection with Anatomical and Experimental Data on the Chyliferous System, Kharkov. M. J. 7:87, 1919.

163. Wallis, R. L. M., and Schölberg, H. A.: On Chylous and Pseudo-Chylous Ascites, Quart. J. Med. 3:301, 1909-1910; 4:153, 1910-1911.

164. Washburn, R. N.: Pathologic Considerations of the Thoracic Duct, Am. J. M. Sc. 196: 572, 1938.

165. Watts, S. H.: Traumatic Chylothorax, Ann. Surg. 74:691, 1921.

166. Whitcomb, B. B., and Scoville, W. B.: Postoperative Chylothorax: Sudden Death Following Infusion of Aspirated Chyle, Arch. Surg. 45: 747, 1942.

167. Williamson, C. S.: A Case of Chylothorax, Internat. Clin. 4:7, 1920.

168. Wurm, H.: Zur Kasuistik der Entzündungen des Ductus thoracicus. Thrombolymphangitis des Halsteils mit Halsvenenthrombose nach hämorrhagischem Lungeninfarkt, Centralbl. allg. Path. u. path. Anat. 39:545, 1927.

169. Wyatt, G. M., and Gross, R. E.: Chylous Ascites: Roentgenological Observations from Cases in Infancy, Am. J. Roentgenol. 45:848, 1941.

170. Yater, W. M.: Non-Traumatic Chylothorax and Chylopericardium: Review and Report of a Case Due to Carcinomatous Thromboangiitis Obliterans of the Thoracic Duct and Upper Great Veins, Ann. Int. Med. 9:600, 1935.

171. Zesas, D. G.: Die nicht operativ enstandenen Verletzungen des Ductus thoracicus, Deutsche Ztschr. Chir. 115:49, 1912.

172. Zesas, D. G.: Die operativ enstandenen Verletzungen des Ductus thoracicus: Ihre Bedeutung; ihre Behandlung, Deutsche Ztschr. Chir. 113: 197, 1911-1912.

DISCUSSION

DR. GORDON F. MADDING, San Mateo, Calif.: I have enjoyed Dr. Burdette's interesting presentation, and it should provide us with considerable help in handling this problem if encountered in the future. I would like to report and briefly discuss a patient with a follow-up of two and one-half years representing the second type of chylous effusion as described by Dr. Burdette, namely, the acute chylous peritoneal effusion or "acute chylous peritonitis," as

it has been designated. It is a rare and unusual condition. In 1956 there were only 24 reported cases in the literature (Madding, G. F.; McLaughlin, R. F., and McLaughlin, R. F., Jr.: Acute Chylous Peritonitis, Ann. Surg. 147:419, 1958).

The patient was a 52-year-old white, unmarried woman, who was first seen by her internist, Dr. Richard McLaughlin, on May 7, 1956, with a presenting history of abdominal pain and swelling of 24 hours' duration, the onset of which followed the ingestion of a heavy meal. There was nausea but no vomiting. Some hours after the onset of pain, the patient noted abdominal swelling, which progressed until the time of surgery. Examination revealed the following significant findings: Temperature was 100 F. There was abdominal distention with generalized tenderness, most marked in the right lower quadrant. Pelvic and rectal examinations were negative. The white blood cell count was 12,700, with 94% segmented forms and 6% lymphocytes. A diagnosis of probable appendicitis was made, and the patient was prepared for surgery. On opening the abdomen, a large amount of milky fluid was noted, and my first impression was that we were dealing with a ruptured appendix. On examination, this organ was found to be uninvolved. A search was then made for a perforated ulcer because of fluid and what appeared to be fibropurulent plaques on the duodenum and intestine. These, however, could not be wiped away and on closer examination were found to be subserosal in nature. In the meantime, fluid from the peritoneum had been sent to the laboratory, for it had been suspected of being chylous in nature. This impression was confirmed by the pathologist. On further exploration the extravasation of chyle was found to involve the mesentery and omentum and extended laterally and anteriorly up over the bladder dome. No gross leak could be found in the chyle system. The peritoneum was essentially negative except for a small ovarian cyst and small uterine fibroids. The appendix and the ovarian cyst were removed, as well as a lymph node and a segment of omentum for study. The abdomen was closed without drainage. On histological examination the appendix was found to be normal. The ovarian cyst was simple in nature, and the lymph node was essentially negative. The omentum revealed large, dilated lymph channels. On the second postoperative day, a swelling occurred in the right posterior triangle of the neck. A chest x-ray taken on the same day, in the search for some etiologic agent which might be responsible for the chyle-duct block, revealed a small accumulation of fluid in the posterior basilar segment of the left lower lobe, as well as the right cervical soft-tissue swelling. The swelling and chest findings completely cleared five days later, and the patient was discharged on the seventh postoperative day. The patient has been on a reduced fat diet since her operation, and, except for four occasions, when she has not followed the diet, her course has been uneventful in the two and one-half years which have elapsed.

As discussed by Dr. Burdette, leakage of chyle may result from trauma of an external nature, as well as from tumors or a disease process involving the thoracic duct. In the case just reported, we felt that "internal trauma" with rupture may have occurred as a result of overloading of the chyle system, following ingestion of a heavy or fat-rich meal. It is necessary in this case to postulate the existence of some pathology involving the lymphatics which would decrease their strength, for under normal circumstances rupture would not occur. It is interesting to speculate that the cervical swelling may have been a cystic hygroma or a cavernous lymphangioma. If such a lesion existed, it is possible that the source of chylous ascites was a ruptured retroperitoneal chylangioma, or lymphangioma, for this area, as well as the cervical region are two of the most frequent sites for the occurrence of such lesions. Of the 24 cases reported, 11, or 44%, occurred without any known etiology. Of this group, seven were explored with a preoperative diagnosis of acute appendicitis.

DR. JOHN T. REYNOLDS, Chicago: I have had one patient who developed a massive chylothorax after esophagectomy. The patient put out such enormous quantities of chyle—4,000 to 5,000 cc. per day—that Dr. Guynn and I felt we had to stop this drainage. We operated upon this man three and one-half weeks after esophagectomy and ligated the thoractic duct in order to stop the drainage. We were criticized because the literature suggested that some of these patients, if treated long enough by aspiration, would recover spontaneously. Our feeling in this case was that this chyle loss was excessive and that it would be less shocking to reoperate upon the patient than to allow continued loss to occur via the chylothorax. I wonder whether Dr. Burdette could give us any information on how we could decide whether one should or should not operate upon these patients?

Dr. John Grindlay, Rochester, Minn.: Experimental work on lymph fistulae and lymph in our laboratory (Dr. J. Mann and others) informs us of one factor that may bear on this problem.

We must remember that all the vitamin K which is absorbed from the bowel enters the blood stream via the lymphatics, and so if there is a complete thoracic-duct fistula, one is losing all vitamin K. There is very little storage of prothrombin in the body, as you know, and so shortly you have the situation where the lymph will no longer clot. If the lymph is clottable, frequently the fistula will close spontaneously. If the fistula remains open and runs briskly for much longer than 36 hours, the lymph will not clot because there is a state of prothrombin deficiency.

The second thing I should like to mention, for whatever it is worth, is that when a thoracic-duct fistula is a complication of radical neck dissection, the fistulous tract may be packed with a little pledget of polyvinyl formalinized (Ivalon) sponge, and from that time on there will be no more leakage. It would appear that just a little deep compression at the site of the leak will serve to raise lymph pressure in the collateral channels of the lymphatic system and to open lymphaticovenous anastomoses.

Dr. Egbert H. Fell, Chicago: Dr. Brown, I apologize for getting up a third time, but I wish to share the advice given us concerning a very serious problem of this nature.

We have had six cases of chylothorax in the past 10 years, five of which responded very well to multiple aspirations, but the sixth one, in a child about 3 years of age, would not respond, and every other day 1,000 cc. or more had to be aspirated.

In discussing this problem with Dr. Bruce Taylor, of our pathology Department, who has had considerable laboratory experience with the thoracic duct systems of animals, he advised us to administer to this child a hypodermoclysis in the thigh at the time of surgery. Believing we should have two or three strings to our bow, we gave some dye by stomach tube just prior to surgery, and the dye did not show up. Starting fluids in the thigh prior to surgery and continuing them until the chest was opened, we found with ease the defect in the thoracic duct from which the chyle came. The defect was closed with fine silk sutures. The difficulty in finding an injury of a thoracic duct is notorious. This experience is presented because it is believed that some in the audience will have a similar problem. The advice given by Dr. Bruce Taylor was of great help to us and our sick little patient.

Dr. Frank McDowell, St. Louis: I can't add much except to say that we have had several of these fistulas in the neck as a consequence of radical neck dissection, in cases where metastases low down at the clavicle were being operated on. Usually, at the time of operation these patients are getting intravenous fluids, and the leak is evident and can be discovered by sponging and using a sucker. The area can be sutured. We don't attempt to repair the leak, but simply use a suture or ligature to occlude it, and these patients usually do not have further trouble. There have been a few cases in which we did not see the leak at operation and it was first discovered that afternoon by profuse milky fluid leaking down the anterior thoracic wall. I think that without exception those patients have done all right by use of very tight pressure dressings over the lower part of the neck. The flow usually stops about the fifth day.

Dr. Walter J. Burdette, Salt Lake City: I wish to thank the discussers for their remarks, in particular for presenting additional cases, so that each clinical type of abnormality of the thoracic duct system has been illustrated this morning by new cases. You will recall that chylous cysts were mentioned in the series reported by Drs. Benson and Reiners yesterday. I have no explanation for the resolution of this condition, which occurs not uncommonly, except that there must be some relief of obstruction or development of collaterals.

In answer to your question, Dr. Reynolds: Experience with cases from the past and our own limited experience indicate a more militant approach toward surgical treatment of this disease than has been the case in the past. One should treat fluid and nutritional deficiencies from the beginning, and I am glad Dr. Grindlay mentioned loss of vitamin K, since restitution of adequate vitamin nutrition should be made as well. Fat emulsions have not been used with sufficient frequency to permit conclusions about their usefulness as supportive treatment.

Aspiration treatment deserves a trial initially, but one should operate on these patients if response is not prompt. From a temporal standpoint, the late stages of the condition may be reached quickly if the loss of chyle is large. The usual figure cited for the amount of

chyle excreted in 24 hours is 2 liters, and occasionally more than that may be aspirated, even from a child.

In support of early operation is the fact that ligation of the duct in the thorax has been done successfully in over 40 cases within the past 10 years. As far as the type of operative treatment is concerned, discovery of the site of the leak or leaks is of the utmost importance, and the suggestion that Dr. Fell has made may be extremely valuable. Besides ligation and excision, even a makeshift type of plug, pressure, or the use of omentum may be successful treatment, particularly when tuberculous abdominal nodes are associated with the condition.

Control of Gastric Secretion by the Antrum

R. C. HARRISON, M.D., F.R.C.S.(C); F. GOUWS, M.D., and H. J. SHIMIZU, M.D., Edmonton, Alta., Canada

Although many theories have been advanced to explain the etiology of duodenal ulcer, there is ample evidence that this is an acid-engendered disease. Patients with duodenal ulcer secrete excessive quantities of acid, both by day and by night, and the gastric and duodenal pH is significantly lower than that of the nonulcer patient. The surgical treatment of duodenal ulcer is directed toward the control of excessive acid secretion; and if acid secretion is significantly reduced, the treatment is effective.

A decade ago it was thought that the physiology of gastric secretion had at last been settled. The secretion of gastrin by the antrum was finally acknowledged to be an important source of gastric acid stimulation. Acid control was stimulated by impulses along the vagi, by food in the region of the antrum, or by food in the intestine. It could be controlled by dividing the vagi, excising the antrum, or removing the acid-secreting cells by gastrectomy.

There was, however, considerable evidence that a mechanism existed whereby acid secretion was terminated when gastric pH became sufficiently low, this evidence having been supplied by Sokolov,[1] Wilhelmj and associates,[2] and others.[3-5] The extremely high incidence of stomal ulceration which resulted when the antrum was left in contact with alkaline duodenal secretion after the Finsterer-Devine exclusion procedures also suggested that the behavior of the antrum was modified by the pH of its environment. Dragstedt and associates found, in the experimental animal, that the usual stimulation of the antrum by food did not occur if the food was in an acid solution.[6] This was an extremely important observation and led logically to the question of whether this might be due to a reduction in gastrin or to the production of an actual inhibitor substance by the antrum. One of us (R. C. H.) and associates[7] suggested in 1956, on the basis of an animal experiment, that the antrum did actually produce an inhibitor substance.

Dragstedt and others[8] had shown previously that when the antrum was transplanted to the colon a marked stimulation in gastric pouch secretion resulted, presumably due to a stimulation of the gastrin mechanism. This did not occur if other portions of the stomach were transplanted, demonstrating that only the antrum produced a stimulus to gastric secretion. We reasoned that if the antrum was in an acid environment, such as that produced by a continued stimulation of acid secretion, it might produce this inhibitor substance if such existed. To maintain a continued hypersecretion, we transplanted the distal half of the antrum to the colon, leaving the proximal half in continuity in the gastrointestinal tract. The effect of blood-borne stimulants was determined by measuring the acid produced by a denervated gastric pouch, first with the antrum remaining in the stomach and later with the antrum removed. Removal of that portion of the antrum remaining in the stomach resulted in increased pouch secretion, suggesting that an inhibitor substance was produced (Figure).

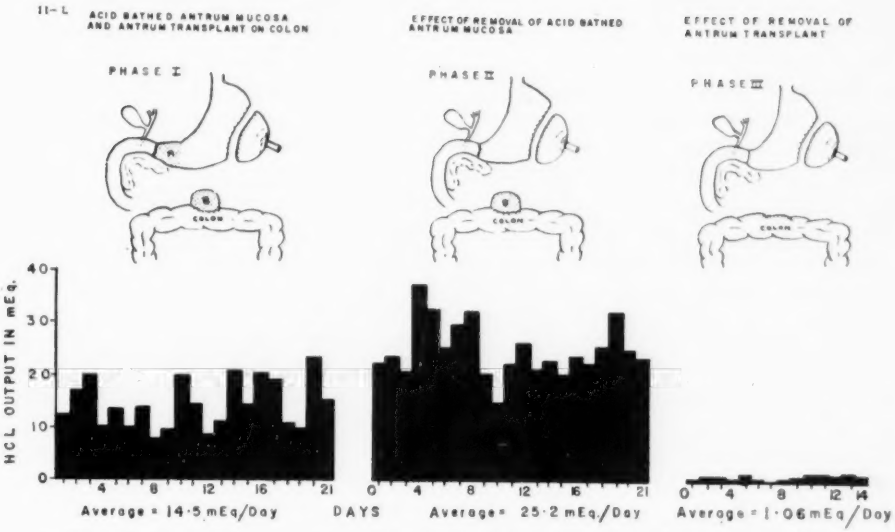
Whether or not an actual inhibitor substance is produced by the antrum is of considerable practical, as well as theoretical,

Aided in part by the National Research Council of Canada.

Edmonton Civic Employees Surgical Fellows (Drs. Gouws and Shimizu).

From the Department of Surgery and the McEachern Laboratory, University of Alberta.

Read at the 66th Annual Meeting of the Western Surgical Association, Rochester, Minn., Nov. 21, 1958.



Plan of the experiment and its effect on pouch secretion. Reproduced from article by Harrison and associates in *Annals of Surgery* (144:441, 1956), by permission of the publishers, J. B. Lippincott Company, Philadelphia.

interest, and whether or not this is modified by vagal denervation is of considerable importance. For this reason the evidence for and against this mechanism will be briefly considered. Both Dragstedt and Woodward and associates [9] have repeated our experiment, the former leaving the antrum innervated, the latter having denervated the gastric half of the antrum. Neither investigator could find any evidence of active inhibition. If gastric acid secretion is stimulated by any mechanism which is not primarily antral in origin, its subsequent inhibition by acidification of the antrum suggests very strongly that an actual inhibitor substance is being produced in the antral area. It is hard to visualize how this could be otherwise; since gastrin is not being produced, the reduction in acid secretion could not be due to a reduction in gastrin release. Thus the reduction in spontaneous secretion in gastric pouches by acidification of the antrum, as demonstrated by both Uvnäs [10] and Woodward [11] and their associates, is evidence in favor of an active inhibitor. Dragstedt and associates [12] have also shown that total gastric pouch secretion under histamine stimulation increases after removal of the antrum, and Woodward and associates [9] have found that acid irrigation of the antrum will inhibit histamine-stimulated pouch secretion. Jordan and Sand,[13] using double antral pouches, showed that acid irrigation of one reduces the stimulation provoked by alcohol irrigation of the other. Also, using double antral pouches, Dragstedt and associates were unable to confirm this experiment.

As has been mentioned, acid secretion can be stimulated by means of the vagi, or by the presence of food in the intestine, these being old and well-established stimulatory mechanisms. Margolus and Harrison [15] demonstrated that gastric pouch secretion stimulated by the intestinal mechanism could be inhibited by acidification of the antrum, and this has been confirmed by Woodward and associates.[9] Shimizu, Morrison, and Harrison [16] have shown that acid production by a vagally innervated gastric pouch (Pavlov pouch), stimulated by insulin-induced hypoglycemia, has likewise been reduced by acidification of the antrum. This suggests that these basic mechanisms of acid stimulation can be partially controlled by modifying the acidity in the region of

the antrum, and is evidence in favor of an inhibitor substance being produced by the antrum.

There is no doubt that the gastrin mechanism is effective whether the antrum is vagally innervated or not, but the influence of vagal innervation in the production of an inhibitor substance is controversial. Thus, in the experiment of Shimizu, inhibition was not as effective when the antrum was denervated; and this was also true when our original experiment was repeated utilizing a denervated antrum.[17] On the other hand, Harkins and associates[18] have some evidence to suggest that the innervated antrum inhibits acid production, whereas the denervated antrum has a stimulatory effect.

Whether the mechanism is a reduction in gastrin, or the production of an inhibitor, or both, there does not appear to be any doubt that the antrum, when bathed with acid, does not stimulate the further production of acid. This is undoubtedly an extremely important mechanism for the regulation of gastric acidity. Presumably, acid secretion is stimulated by the vagi when food is contemplated, smelled, visualized, or tasted. Secretion is further stimulated when the food reaches the antrum, unless free acid is present in sufficient quantities to maintain an acid environment in the antral region. Thus, whether or not further acid is stimulated by the antral mechanism will depend upon the pH following the interaction between the ingested food and the acid stimulated by the vagal route. When the food has left the stomach, a continuation of acid secretion by the antral mechanism will cease when undiluted acid comes in contact with the antrum. Meanwhile, food in the intestine also tends to stimulate further acid secretion, although it is established that this mechanism is not nearly as effective as the vagal or antral phase. It can be appreciated, however, that if an active inhibitor mechanism is present in the antrum, it will terminate further acid secretion in a much more effective manner than the simple cessation of gastrin production.

The procedures for the surgical treatment of duodenal ulcer at this time can be divided into two large groups, depending on whether or not the antrum is preserved. Those who resect the antrum believe that it is primarily a gastric-acid stimulator, whereas those who preserve it feel that the antrum in an acid environment will not stimulate further acid production, that it secretes an alkaline mucus, that it might actually inhibit the overproduction of acid, and that, with the pylorus, it is a very useful physiological mechanism for the control of gastric emptying. Nothing is to be gained by argument, for only further clinical and experimental work will clarify the situation. It is not proved that an active inhibitor is produced by the antrum, nor is it proved that these mechanisms exist in the human, or at what pH the mechanisms come into play. If such mechanisms exist, it is not known how vagal denervation affects them. It is known that the antrum left bathed with alkaline secretion results in a very high incidence of recurrent ulceration, and it is known that the antrum does not secrete hydrochloric acid.

Suite 241, University Hospital.

REFERENCES

1. Pavlov, I. P.: The Work of the Digestive Glands, translated by W. H. Thompson, Ed. 2, London, Charles Griffin & Co., 1910.

2. Wilhelmj, C. M.; O'Brien, F. T., and Hill, F. C.: The Influence of the Pylorus on the Secretion of Acid by the Fundus, Am. J. Physiol. 116: 685, 1936.

3. Day, J. J., and Webster, D. R.: Autoregulation of the Gastric Secretion, Am. J. Digest. Dis. 2:527, 1935.

4. Code, C. F., and Watkinson, G.: Importance of Vagal Innervation in the Regulatory Effect of Acid in the Duodenum on Gastric Secretion of Acid, J. Physiol. 130:233, 1955.

5. Pincus, I. J.; Thomas, J. E., and Rehfuss, M. E.: A Study of Gastric Secretion as Influenced by Changes in Duodenal Acidity, Proc. Soc. Exper Biol. & Med. 51:367, 1942.

6. Dragstedt, L. R.; Oberhelman, H. A., Jr.; Woodward, E. R., and Smith, C. A.: Interrelation

Between the Cephalic and Gastric Phases of Gastric Secretion, Am. J. Physiol. 171:7, 1952.

7. Harrison, R. C.; Lakey, W. H., and Hyde, H. A.: The Production of an Acid Inhibitor by the Gastric Antrum, Ann. Surg. 144:441, 1956.

8. Dragstedt, L. R.; Woodward, E. R.; Oberhelman, H. A.; Storer, E. H., and Smith, C. A.: Effect of Transplantation of Antrum of Stomach on Gastric Secretion in Experimental Animals, Am. J. Physiol. 165:386, 1951.

9. Woodward, E. R.; Turnbull, W. E.; Schapiro, H., and Towne, L.: Does the Gastric Antrum Elaborate an Antisecretory Hormone? Am. J. Digest. Dis. 3:204, 1958.

10. Uvnäs, B.; Andersson, S.; Elwin, C.-E., and Malm, A.: The Influence of Exclusion of the Antrum-Duodenum Passage on the HCl Secretion in Pavlov Pouch Dogs, Gastroenterology 30:790, 1956.

11. Woodward, E. R.; Lyon, E. S.; Landor, J., and Dragstedt, L. R.: The Physiology of the Gastric Antrum, Gastroenterology 27:766, 1954.

12. Ragins, H.; Rigler, S. P.; Evans, S. O.; McCarthy, J. D., and Dragstedt, L. R.: Studies on the Physiology of the Gastric Antrum, A. M. A. Arch. Surg. 75:230, 1957.

13. Jordan, P. H., Jr., and Sand, B. F.: A Study of the Gastric Antrum as an Inhibitor of Gastric Juice Production, Surgery 42:40, 1957.

14. Longhi, E. H.; Greenlee, H. B.; Bravo, J. L.; Guerrero, J. D., and Dragstedt, L. R.: Question of an Inhibitory Hormone from the Gastric Antrum, Am. J. Physiol. 191:64, 1957.

15. Margolus, B. D., and Harrison, R. C.: Inhibition of the Intestinal Phase of Gastric Secretion by Antral Inhibitor Substance, S. Forum 7:360, 1957.

16. Shimizu, H. J.; Morrison, R. T., and Harrison, R. C.: Inhibition of Vagally Stimulated Gastric Acid by the Pyloric Antrum, Am. J. Physiol. 194:531, 1958.

17. Gouws, F., and Harrison, R. C.: The Influence of the Vagus Nerve on Antral Function, Canad. J. Surg. 1:337, 1958.

18. Jones, T. W.; Stevenson, J. K.; Jesseph, J. E.; Nyhus, L. M., and Harkins, H. N.: Heidenhein Pouch Secretory Response to Transplantation of the Innervated and Denervated Antral Pouch to the Transverse Colon, Ann. Surg. 147:13, 1958.

DISCUSSION

DR. GEORGE A. HALLENBECK, Rochester Minn.: I welcome the invitation of Dr. Harrison to discuss this excellent paper. Our knowledge of the gastric secretory process certainly has a way of rearranging itself just as it appears to become somewhat stabilized.

Dr. Harrison and his associates have devised ingenious experiments, not all of which by any means were presented here, to answer the question: "Does the antrum liberate a substance which inhibits gastric secretion, or are its apparent effects in this direction merely results of cessation of the secretion of gastrin?"

Still controversial, this question has stimulated study by other groups of workers as well—studies which inevitably increase our knowledge of the physiological processes involved. As usual, clinical applicability is very hard to predict. Although based first on experimental data, the decision as to whether the antrum should be preserved to use its capacity for inhibiting gastric secretion under appropriate circumstances will depend finally, I believe, on the comparison of results of clinical trials. This, of course, is the point Dr. Harrison made. We shall have to wait some time before we have the answer.

The bulk of our understanding of the mechanisms by which gastric secretion is controlled comes from studies on dogs. Studies on man present difficulties in the control of many variables. Dr. Fernand Schmidt and I recently studied the effect of acid administered intragastrically on secretion of acid in response to a liquid test meal of liver extract in man. Inhibition occurred when the pH of the test meal was 1.0 but not when it was 1.5 or more (A. M. A. ARCH. SURG. 77:26, 1958).

I recently learned that Wilhelmj and Sachs performed similar tests on man in 1939 (*Am. J. Digest. Dis.* 6:467, 1939). The studies show that in man some mechanism does exist whereby acid in the stomach can inhibit further secretion of acid by the gastric mucosa, although the acidity has to be quite marked. It is heartening when experiments on man confirm in a general way those on dogs.

Again let me congratulate Dr. Harrison on the excellent paper he presented today, and on the excellent work he has been doing in this field.

Diphasic Blood Ammonia Curves After Feeding Protein to Normal Dogs and Men

JAMES S. CLARKE, M.D.; KENNETH CRUZE, M.D.; PAUL K. McKISSOCK, M.D., and ROBERT S. OZERAN, M.D., Los Angeles

We[1,2] have confirmed the findings of others[3-6] that there is an elevation in acid secretion from Heidenhain pouches of dogs, in which the portal venous blood is diverted around the liver. The elevated secretion is intimately related to the ingestion of food.[2-5] We thought the humoral secretagogue involved might be a product of protein breakdown in the lumen of the intestine. Since ammonia is one such product which can conveniently be measured, we set out to study serial venous blood ammonia levels after feeding dogs with and without shunts around the liver, seeking to determine whether there is a correlation between these levels and the rate of gastric acid secretion. The ammonia curves obtained after feeding normal dogs and men were surprising and are the subject of this report.

Methods

Normal mongrel intact, unanesthetized dogs weighing between 12.7 and 25.0 kg., were fasted but were allowed to drink water for 20 hours prior to testing. Blood ammonia was measured by Conway's technique,[7] pipetting the blood into the outer chamber of the Conway dish five minutes after shedding and using a 10-minute diffusion time. Six types of experiments were done on dogs.

1. Five dogs had determinations of the ammonia content of blood drawn from peripheral veins at half-hour intervals for six hours under conditions of continuing fast.

2. Fifteen similar serial studies on 14 dogs were done after feeding a meal of 906 gm. of a commercial dog food (Pup-O), which contains 10% protein, or 200-600 gm. of liver, beef, or fish scraps.

3. Similar studies were done on five dogs fed 380-800 gm. of beef fat from which all grossly visible meat had been removed.

4. Similar studies were done on five dogs fed 115-500 gm. of white bread.

5. Serial peripheral venous ammonia levels were measured on each of five dogs fed 10 gm. of dibasic ammonium citrate (0.5-0.7 gm/kg.) mixed with a small amount of meat.

6. In each of 10 dogs at operation a polyethylene catheter was passed into the portal vein through a small tributary. The tip was placed 1-2 cm. from the hilus of the liver, and the catheter was led through a stab wound in the abdominal wall to a subcutaneous location. The catheter was filled with heparinized saline, and its subcutaneous end was ligated, the skin being closed over it. Two to seven days after this initial operation, when the dog had fully recovered, the catheter end was delivered under local anesthesia. Each dog, which had fasted 20 hours, was fed a meal of 906 gm. of a commercial dog food (Pup-O or Friskies), which contains 10% protein, or 200-600 gm. of liver, beef, or fish scraps. Blood was obtained at half-hour intervals from the portal vein through the catheter and from a peripheral vein by venipuncture. Thus, serial ammonia levels were determined for each of the two veins simultaneously for five to six hours after feeding.

Finally, 13 normal male human volunteers, who had fasted for 14 hours, ate an appetizing meal of beef, peas, potatoes, cheese, custard, milk and coffee, which contained 82 gm. of protein, 33 gm. of fat, and 40 gm. of carbohydrate. Peripheral venous blood ammonia levels were determined in the fasting state and every half-hour for six hours after eating.

Results

Normal fasting venous blood ammonia levels for our dogs ranged from 22μg. to 70μg. of ammonia nitrogen per 100 ml., the mean of 38 determinations being 43.2$\pm$12.1

Read at the 66th Annual Meeting of the Western Surgical Association, Rochester, Minn., Nov. 21, 1958.

This investigation was supported by Research Grant H-3066 from the National Heart Institute, U. S. Public Health Service.

From the Surgical Service, Veterans Administration Center, and the Department of Surgery, University of California Medical Center.

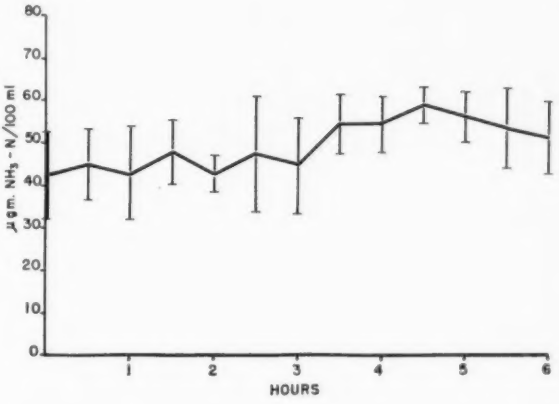


Fig. 1.—Ammonia content of peripheral venous blood of five normal fasting dogs, showing means and standard deviations.

(S. D.). The venous blood ammonia did not vary significantly during fasting (Fig. 1).

The individual ammonia curves in the 15 experiments in which protein was fed are shown in Figure 2. The control (zero hour) sample was drawn just before feeding. Each dog had a rise above the control ammonia level within one-half to one hour after eating. A subsequent fall toward base-line values was followed by a second rise at four to five hours after eating. In nine tests the initial peak exceeded 100μg. NH_3-N/100 ml. and in nine the second peak did likewise. The highest early rises were seen when liver or beef was fed (Dogs 94, 146, and 164). The means and standard deviations for each half-hour after protein feeding are given in Figure 3.

Figure 4 shows the means and standard deviations of the venous blood ammonia in five dogs after eating a meal of beef fat. None of these dogs showed an early rise, but each of them had a distinct late rise at five to six hours after feeding.

Figure 5 shows the effect on blood ammonia of a meal of white bread in five dogs. No recognizable early or late rise could be seen in any of the animals.

Figure 6 shows the mean ammonia levels in five dogs which each ate 10 gm. of diammonium citrate. None showed any significant rise in the venous blood ammonia.

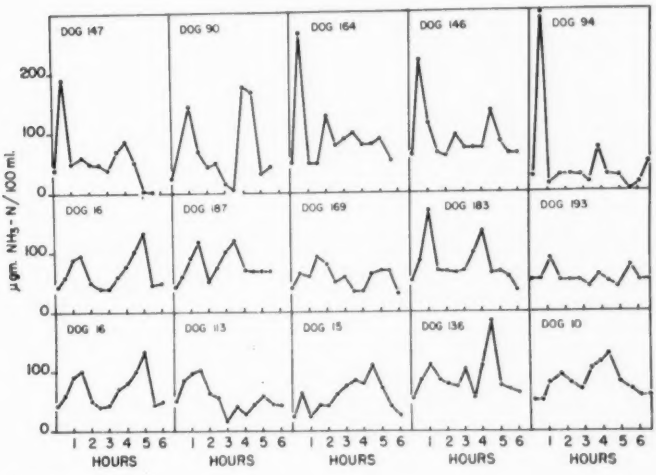


Fig. 2.—Individual venous blood ammonia curves obtained after feeding a protein-containing meal to normal dogs.

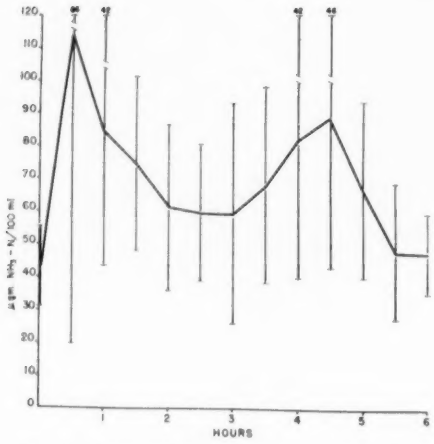


Fig. 3.—Ammonia content of peripheral venous blood after feeding a protein-containing meal to normal dogs: Composite graph showing means and standard deviations of 15 feeding experiments.

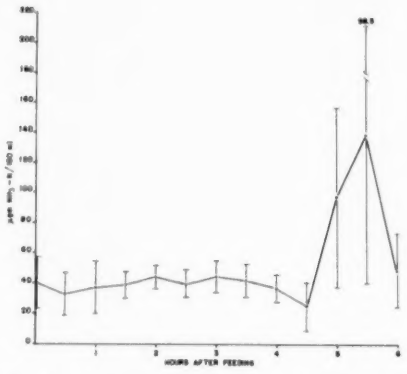
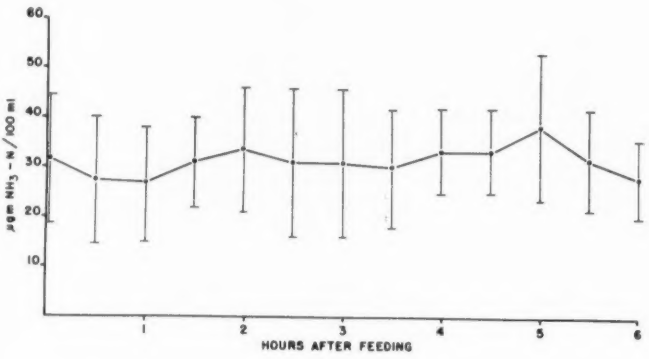


Fig. 4.—Ammonia content of peripheral venous blood of five normal dogs after eating a meal of beef fat. Graph showing means and standard deviations.

Fig. 5.—Ammonia content of peripheral venous blood after feeding a meal of white bread to five normal dogs, showing means and standard deviations.



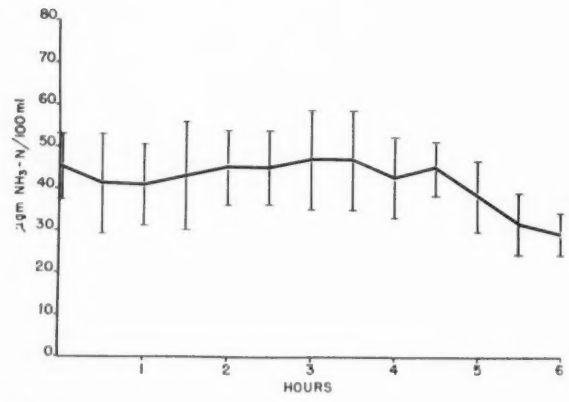


Fig. 6.—Ammonia content of peripheral venous blood of five normal dogs after ingesting 10 gm. of dibasic ammonium citrate (0.5-0.7 gm/kg.), showing means and standard deviations.

Fig. 7.—Representative experiment showing ammonia levels in portal and peripheral venous blood after feeding a protein-containing meal to a normal dog (Dog 67).

The data obtained from each of the 10 dogs in which simultaneous portal and peripheral venous ammonia levels were determined were similar. The results of a representative experiment, consistent with the findings in the other nine, are given in Figure 7. The diphasic rise in peripheral venous ammonia was present in all these animals, the early rise occurring at one-half to three hours and the late rise from three and a half to six hours after feeding. The ammonia content of portal venous blood showed a diphasic rise in each instance, the peaks corresponding in time with those in peripheral venous blood. The mean fasting portal venous ammonia level was 269μg. NH_3-N/100 ml. (range 120μg.-480μg.). The average of the highest of the two portal blood ammonia peaks attained for each dog was 533μg. NH_3-N/100 ml. (range 310μg.-1,245μg.).

Nine out of thirteen normal men showed a recognizable double rise in their peripheral venous ammonia after eating a protein-containing meal. Figure 8 shows a representative experiment. Two men showed only a late rise, and two showed no recognizable rise. The mean of the control values was 75μg. NH_3-N/100 ml. The mean of the peaks attained was 140μg. NH_3-N/100 ml. (range 76μg.-220μg.).

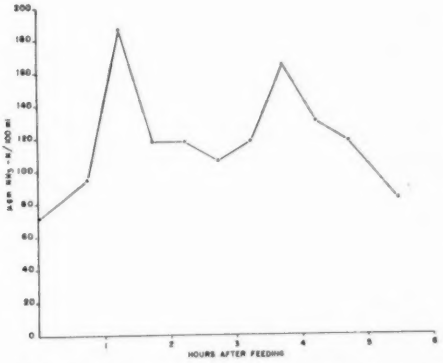


Fig. 8.—Representative experiment showing ammonia levels in peripheral venous blood of a normal man after eating a protein-containing meal.

Comment

We have found few reports of serial blood ammonia measurements done during the first few hours after feeding protein-containing diets. Zimmerman, Korn, and Weinstein[8] fed a gelatin meal to normal and cirrhotic subjects and found a rise in blood ammonia at two to four hours. After intragastric administration of whole blood to normal men, Young and co-workers[9] noted a slow rise of blood ammonia to a moderate peak at three hours, with return to base-line values at nine hours. Neither group found a diphasic curve, perhaps because the intervals between determinations were too long, or because the diphasic curve is absent in humans fed these test substances.

Though there are many studies of peripheral blood ammonia after oral administration

of ammonium salts, we have found none that revealed a diphasic curve. Serial blood ammonia estimations after oral or intrajejunal administration of dibasic ammonium citrate were used by Eiseman et al.[10] and by Levine and Rigler[11] to test for patency of portacaval shunts. When doses of 0.5 gm/kg. were used, peripheral venous blood ammonia rose slightly or not at all in normal dogs, but showed a prompt distinct single rise of several hours' duration in dogs with open shunts. Our failure to note ammonia rises in five normal dogs after feeding 0.5-0.7 gm/kg. of dibasic ammonium citrate is in accord with these results. On the other hand, Koprowski and Uninski[12] found a consistent, prompt, and high rise in blood ammonia of dogs given 0.5 gm/kg. of ammonium chloride by mouth, and moderate rises were seen in normal humans after an oral dose of 3 gm. of ammonium chloride.[13,14]

The discrepancy in findings concerning elevation of blood ammonia of normal animals after ingestion of various ammonium salts may be related to differences in dosage, since 1 gm. of ammonium chloride contains 0.272 gm. of ammonium nitrogen, and 1 gm. of dibasic ammonium citrate contains 0.124 gm. of ammonium nitrogen. The discrepancy may also be related to pH changes, since Lawrence et al.[15] showed that lowering pH increased total ammonia levels in canine blood. The results cited are consistent with the idea that ingested ammonium is absorbed from the upper gastrointestinal tract, and normally is converted effectively to urea in the liver. In the presence of perihepatic venous shunts the ammonium bypasses the liver, and with sufficiently large doses of ammonium salts it is not completely metabolized as it traverses the liver. Then peripheral blood ammonia rises.

The finding of a diphasic venous blood ammonia curve after protein feeding has several interesting implications. It suggests that the ability of the liver to metabolize adequately the ammonia presented to it in the portal blood may be exceeded even under these physiological conditions, and a spill over of ammonia into the peripheral blood occurs. The high double rise in portal venous blood, coinciding in time with the peripheral double rise, lends support to this view. It also suggests that the source of the ammonia lies in the intestine rather than in the liver itself. The absence of the peripheral rise after eating 10 gm. of ammonium citrate, yet its presence after eating protein food, is surprising, and again indicates that there may be a large influx of ammonia into the portal blood very soon after eating.

The rises found in these experiments were not due to large amounts of ammonium salts in the protein meal, since the amount of free ammonia in the dog food and liver given were very small relative to the amount in 10 gm. of ammonium citrate. The dog food (Pup-O) contained by our analysis 0.324 gm. of NH_3-N/906 gm. and the liver 0.531 gm. of NH_3-N/200 gm., as compared with 1.24 gm. of NH_3-N/10 gm. of dibasic ammonium citrate. However, the protein meals contained much more total nitrogen than did 10 gm. of ammonium citrate, there being 13.4 gm. of nitrogen (N) in 906 gm. of Pup-O and 8.88 gm. of nitrogen in 200 gm. of liver. Thus, if a large proportion of this protein nitrogen were converted to ammonia after ingestion, the dose of ammonia from feeding protein could far have exceeded that from taking 10 gm. of dibasic ammonium citrate.

An alternative hypothesis to explain the rise in peripheral venous blood "ammonia" is that it does not represent free ammonia at all but is due to some compound which releases ammonia after the blood is shed or when it is mixed with alkali in the Conway dish. Certain amino acids release ammonia when blood is mixed with alkali, and we employed the correction for this in our calculations, as recommend by Conway.[7] The known rise in blood amino acids after feeding is to two to three times control levels,[16] and this is insufficient to account for the degree of the postprandial rise in blood ammonia. Whether these rises after eating are due to free ammonia or to some am-

monia-releasing compounds remains undetermined.

The diphasic curve may require modification of prevailing ideas about the relative importance of the sites of ammonia formation and absorption from the intestinal tract. Although gastric urease has received extensive study, the contribution of the stomach to portal blood ammonia has been considered slight.[17] Folin and Denis,[18] and more recently Silen et al.,[19] measured the ammonia content of various portal-vein tributaries in fasting anesthetized dogs and cats. Since the ammonia content of venous blood from the colon was much greater than that from other parts of the gastrointestinal tract, they concluded that the colon, with its heavy concentration of ammonia-forming bacteria, is the primary site of intestinal ammonia formation. This conclusion may be valid for their experimental conditions, but may not hold for the intact, unanesthetized, eating animal. The early rise in portal and peripheral blood ammonia after eating could mean that ammonia is released in large quantities from the upper intestinal tract under these circumstances. Another possible interpretation is that the early rise is due to enhanced absorption of ammonia from the colon, due to churning of colonic contents from the gastrocolic reflex. In any case the relative importance of the various parts of the intestinal tract in ammonia formation, particularly after meals, needs further study.

The late rise in blood ammonia coincides in time with the arrival of the ingested meal at the distal portion of the ileum and the colon. It seems possible to us that it reflects an influx of ammonia into the portal blood resulting from the action of ammonia-forming bacterial enzymes on the protein meal. Its relatively brief duration might well be due to the existence of adjustable ammonia-removal mechanisms, as postulated by Webster and Davidson.[20] These authors found that during constant-rate infusions of ammonium-containing substances there was often a decrease in blood ammonia, following a primary rise.

The findings after feeding meals of bread and of beef fat are puzzling, and we have no ready explanation for them. According to standard dietetic tables,[21] white bread contains 8.2% protein, 3.3% fat, and 52.3% carbohydrate. Despite the protein content of the bread meal, no postprandial rise in blood ammonia ensued. This finding, and the previously cited[8,9] results of feeding gelatin and blood, force the conclusion that the diphasic rise is a function of the type and, perhaps, the quantity of food eaten, and is not seen after ingestion of all types of protein meal. The presence of the second rise after feeding beef fat suggests that it may be related to intestinal motility changes rather than to the nitrogenous content of the meal.

The diphasic ammonia curve in normal humans after eating has obvious clinical implications. If possible, blood for ammonia determination should be drawn from the patient when he has fasted at least six hours.

Summary

Normal dogs fed a protein-containing meal showed a diphasic curve in their peripheral venous blood ammonia levels. A concomitant, and higher, double rise was seen in the ammonia content of portal venous blood. The first rise usually occurred within one-half to one hour after eating; the second four to five hours after eating. No rises occurred during fasting, or after feeding white bread or dibasic ammonium citrate. Only the late rise occurred after feeding beef fat.

Nine of thirteen normal men showed a diphasic venous blood ammonia curve after eating a protein meal.

This suggests that the upper intestinal tract may contribute important quantities of ammonia to the portal blood under postprandial conditions, although alternative interpretations are possible.

To measure basal ammonia levels, blood should be drawn at least six hours after the patient has eaten.

Sabri El Farra, Valda Crevling, James Rizer, and Elijah Williams gave technical assistance.

Veterans Administration Center (25).

REFERENCES

1. Clarke, J. S.; Hart, J. C., and Ozeran, R. S.: Increase in Heidenhain Pouch Secretion After Portacaval Transposition in the Dog, Proc. Soc. Exper. Biol. & Med. 97:118-121 (Jan.) 1958.

2. Clarke, J. S.; Ozeran, R. S.; Hart, J. C.; Cruze, K., and Crevling, V.: Peptic Ulcer Following Portacaval Shunt, Ann. Surg. 148:551-566 (Oct.) 1958.

3. Lebedinskaja, S. I.: Über die Magensekretion bei Eckschen Fistelhunden, Ztschr. ges. exper. Med. 88:264-270 (April) 1933.

4. Gerez, L., and Weiss, A.: Über die Magensaftsekretion bei Eckscher Fistel, Ztschr. ges. exper. Med. 100:281-288 (March) 1937.

5. Gregory, R. A.: The Effect of Portal Venous Occlusion on Gastric Secretion, J. Physiol. 137: 76P-77P (Aug. 6) 1957.

6. Dubuque, T. J., Jr.; Mulligan, L. V., and Neville, E. C.: Gastric Secretion and Peptic Ulceration in the Dog with Portal Obstruction and Portacaval Anastomosis, S. Forum 8:208-211, 1957.

7. Conway, E. J.: Microdiffusion Analysis and Volumetric Error, 4th rev. ed., London, Crosby Lockwood & Son, Ltd., 1957, p. 121.

8. Zimmerman, H. J.; Korn, R. J., and Weinstein, H. G.: Observations on the Source of Elevated Plasma Ammonia Levels in Hepatic Insufficiency, Am. J. M. Sc. 231:177-185 (Feb.) 1956.

9. Young, P. C.; Burnside, C. R.; Knowles, H. C., Jr., and Schiff, L.: Effects of Intragastric Administration of Whole Blood on the Concentration of Blood Ammonia in Patients with Liver Disease, J. Lab. & Clin. Med. 50:11-16 (July) 1957.

10. Eiseman, B.; Lindeman, G., and Johnson, J.: A Method for Determining the Patency of a Portacaval Shunt, S. Forum 5:200-204, 1954.

11. Levine, R. S., and Rigler, S. P.: Studies on the Ammonia Tolerance Curve in Dogs with Portacaval Shunts, S. Forum 8:235-239, 1957.

12. Koprowski, H., and Uninski, H.: Ammonia Content of Canine Blood After Oral Administration of Ammonium Salts and Ammonia, Biochem. J., 33:747-753 (May) 1939.

13. Traeger, H. S.; Gabuzda, G. J., Jr.; Ballou, A. N., and Davidson, C. S.: Blood "Ammonia" Concentration in Liver Disease, and Liver Coma, Metabolism 3:99-109 (March) 1954.

14. White, L. P.; Phear, E. A.; Summerskill, W. H. J., and Sherlock, S.: Ammonium Tolerance in Liver Disease: Observations Based on Catheterization of the Hepatic Veins, J. Clin. Invest. 34: 158-168 (Feb.) 1955.

15. Lawrence, W., Jr.; Jacquez, J. A.; Dienst, S. G.; Poppell, J. W.; Randall, H. T., and Roberts, K. E.: The Effect of Changes in Blood pH on the Plasma Total Ammonia Level, Surgery 42:50-60 (July) 1957.

16. Dent, C. E., and Schilling, J. A.: Studies on the Absorption of Proteins: The Amino-Acid Pattern in the Portal Blood, Biochem. J. 44:318-333, 1949.

17. Kornberg, H. L., and Davies, R. E.: Gastric Urease, Physiol. Rev. 35:169-177 (Jan.) 1955.

18. Folin, O., and Denis, W.: Protein Metabolism from the Standpoint of Blood and Tissue Analysis: II. The Origin and Significance of the Ammonia in the Portal Blood, J. Biol. Chem. 11: 161-167, 1912.

19. Silen, W.; Harper, H. A.; Mawdsley, D. L., and Weirich, W. L.: Effect of Antibacterial Agents on Ammonia Production Within the Intestine, Proc. Soc. Exper. Biol. & Med. 88:138-140 (Jan.) 1955.

20. Webster, L. T., Jr., and Davidson, C. S.: Cirrhosis of the Liver: Impending Hepatic Coma and Increased Blood Ammonium Concentrations During Protein Hydrolysate Infusion, J. Lab. & Clin. Med. 50:1-10 (July) 1957.

21. McLester, J. S., and Darby, W. J.: Nutrition and Diet in Health and Disease, Ed. 6, Philadelphia, W. B. Saunders, Company, 1952, p. 635.

DISCUSSION

DR. WILLIAM SILEN, Denver: Both Dr. Eiseman and I have followed with interest Dr. Clarke's work and have been most interested in the results that he reports. We are rather surprised at the finding that in a normal animal or a normal human these rises occur in peripheral blood ammonia. We have noticed that even in animals with shunts, such as portacaval transposition animals, it is really very difficult to get rises in peripheral blood ammonia. The methods which are used to determine blood ammonia at the present time are rather crude, and I should question a bit the significance of the magnitude of the rises in some of the animals reported by Dr. Clarke.

DR. JAMES S. CLARKE, Los Angeles: I should like to thank Dr. Silen for his discussion. He raises a question that is certainly pertinent. Blood ammonia assays are hard to do, and it is hard to know how much one can count on them. I feel, however, that the data we have obtained are sufficiently consistent, and all seem to point pretty much in the same direction. I think they are significant.

It is really hard to know what the diphasic rise that we see means. It could mean that ammonia is formed in significant quantities, perhaps in the upper gastrointestinal tract soon after eating, and that this causes this pulse of ammonia into the portal blood which is seen shortly after eating. It could be simply on the basis of motility changes in the intestine. We have thought that possibly the churning of the colonic contents by the gastrocolic reflex soon after eating could cause liberation of ammonia into the intestinal tract. The third possibility is that we may not be measuring ammonia at all, but may be concerned with some other substance that is measured by the Conway technique and from which ammonia is liberated when the blood is shed or mixed with alkali in the Conway diffusion chamber.

DR. JOHN GRINDLAY, Rochester, Minn.: Did you give any of your dogs enemas at the time of this secondary rise, or did you give them antibiotics? From our work we would suspect that this is the result of bacterial action and absorption.

DR. JAMES S. CLARKE, Los Angeles: We have not done those experiments, Dr. Grindlay. However, we have determined ammonia curves in a few patients who have ileostomies, with the idea of trying to rule out the colon as a source of the ammonia. As a preliminary impression, we have found that the diphasic curve was absent in two patients who have ileostomies.

Control of Ammonia Production in the Colon with Neomycin Enemas

JOHN S. NAJARIAN, M.D.; JACK JEW, M.D.; RICHARD L. DAKIN, M.D.; HAROLD A. HARPER, Ph.D.; CLARA M. QUINNELL, Ph.D., and H. J. McCORKLE, M.D., San Francisco

The ammonia that occurs in the blood originates mainly in the colon, where it is produced as a result of the action of intestinal bacteria on nitrogenous substances.[1,2] Sterilization of the intestine by the use of orally administered antibiotics greatly reduces the amount of ammonia in the venous blood from the colon.[3,4] Neomycin has been shown both experimentally [5] and clinically [6,7] to be the most effective currently available antibiotic to reduce ammonia production in the gastrointestinal tract. During the course of treatment of some patients with ammonia intoxication it may be impossible to give the antibiotic by mouth; therefore, the following experimental and clinical investigations of the effectiveness and safety of the administration of neomycin by enema were done.

Methods and Material

In 12 dogs laparotomies were performed and polyethylene catheters were sutured into their portal veins. The distal ends of these catheters were placed in easily accessible locations beneath the skin for sampling of portal vein blood. These animals were then fed 750 gm. of raw horse meat daily for three days. On the fourth day samples of blood were taken from their portal veins via the previously placed catheters and the ammonia content of the blood was measured. Specimens of the stools were obtained for bacterial culture. Ten of these animals were then given saline enemas, followed by retention enemas of 1% neomycin solution.* The other two animals were given only saline enemas. Following the enema, samples of portal venous blood were drawn every hour for six hours and examined for their ammonia content. Peripheral venous blood samples were taken for serum neomycin determinations at three and six hours following the enemas. The blood ammonia concentrations were determined by the microdiffusion technique of Conway.[8] The serum neomycin concentrations were determined by biological assay, using a tube serial dilution technique with Bacillus subtilis as the test organism.[9] Stool specimens for culture were also obtained at three and six hours after the enema. They were weighed, and the stool culture material was then suspended in thioglycolate broth. In order to minimize the bacteriostatic effect of neomycin, serial dilutions from 1:1,000, to 1:1,000,000 were made. An aliquot of 0.1 ml. of each of these dilutions was then cultured on eosin-methylene-blue medium to obtain growth of coliform organisms, in pour plates of Wilson-Blair medium for clostridia, and in beef-heart medium at pH 9.3 for enterococci. All cultures were examined for growth after 24 and 48 hours of incubation. Christensen's urea-agar medium pour plates were used to determine the urease activity of the bacteria.

Results

The results of the stool cultures before and after neomycin or saline enemas are shown in Table 1. In all but two determinations, the stool bacterial cultures taken three hours following neomycin enemas showed no growth of enterococci or coliform organisms. Neomycin was not effective against clostridia, and these organisms remained viable after three and six hours in cultures taken from all the animals (Fig. 1). However, these clostridia were urease-nega-

Read at the 66th Annual Meeting of the Western Surgical Association, Rochester, Minn., Nov. 21, 1958.

From the Surgical Research Laboratories and the Department of Surgery of the University of California School of Medicine.

Supported by the National Institute of Arthritis and Metabolic Diseases (Grant A-1053) and the Christine Breon Fund for Medical Research.

* The neomycin was supplied through the courtesy of The Upjohn Company, Kalamazoo, Mich.

TABLE 1.—*Effect of Neomycin or Saline Enemas on Bacterial Flora of Colon*

Dog No.	Bacteria	Before Enema	After Enema 3 Hr.	After Enema 6 Hr.
		No. of Bacteria Per Gram of Stool		
		Neomycin Enemas		
50	Coliform	3×10^8	0	0
	Enterococci	2×10^8	0	0
	Clostridia	1×10^8	1×10^8	0
257	Coliform	2×10^8	0	0
	Enterococci	4×10^7	NS	0
	Clostridia	4×10^7	0	2×10^8
137	Coliform	2×10^8	0	0
	Enterococci	2×10^7	0	0
	Clostridia	3×10^8	9×10^8	2×10^8
261	Coliform	2×10^8	0	0
	Enterococci	4×10^7	NS	0
	Clostridia	3×10^8	0	2×10^8
288	Coliform	9×10^8	0	0
	Enterococci	1×10^8	0	0
	Clostridia	9×10^8	2×10^8	2×10^8
262	Coliform	2×10^8	0	0
	Enterococci	2×10^7	0	0
	Clostridia	6×10^7	6×10^8	1×10^8
188	Coliform	2×10^8	2×10^8	7×10^8
	Enterococci	2×10^8	0	2×10^8
	Clostridia	7×10^7	4×10^8	4×10^8
263	Coliform	4×10^8	0	0
	Enterococci	3×10^8	0	0
	Clostridia	2×10^8	9×10^8	1×10^7
2	Coliform	5×10^8	0	0
	Enterococci	2×10^8	0	0
	Clostridia	2×10^7	6×10^8	4×10^8
10	Coliform	2×10^8	7×10^8	1×10^8
	Enterococci	2×10^8	1×10^8	1×10^8
	Clostridia	1×10^8	2×10^8	1×10^8
		Saline Enemas		
47	Coliform	3×10^8	6×10^8	4×10^7
	Enterococci	2×10^8	5×10^8	7×10^7
	Clostridia	2×10^8	1×10^7	4×10^8
243	Coliform	4×10^8	2×10^8	1×10^7
	Enterococci	2×10^8	2×10^7	3×10^6
	Clostridia	5×10^8	6×10^8	6×10^8

tive on urea-agar medium and therefore probably did not contribute substantially to ammonia production. In the cultures of stool specimens from animals given only saline enemas, all the bacteria remained viable after three and six hours, with only a minimal variation, which probably was due to dilution by the enema (Fig. 2).

TABLE 2.—*Ammonia Concentrations in Portal Blood Prior and Subsequent to Neomycin and Saline Enemas*

Dog No.	NH_3N Before Enema, μg/100 Ml.	NH_3N After Enema, μg/100 Ml. 1 Hr.	2 Hr.	3 Hr.	4 Hr.	5 Hr.	6 Hr.
		Neomycin Enemas					
50	160	125	95	95	215	195	125
257	87	150	150	195	195	162	--
137	262	238	238	138	218	--	--
261	188	270	230	210	210	--	--
288	348	520	520	345	312	288	222
262	250	175	193	372	286	342	222
188	200	213	135	157	262	270	255
263	243	128	288	329	156	242	178
2	278	255	276	278	221	232	319
10	80	157	246	246	257	195	169
		Saline Enemas					
47	264	220	193	310	286	280	259
243	217	232	225	257	301	274	246

The portal vein ammonia concentrations determined before and after neomycin and saline enemas are shown in Table 2. In these 12 dogs no consistent change in portal blood ammonia concentration was detected, apparently because of mixing of the blood from the colon, which is high in ammonia, with that from the remainder of the gastrointestinal tract, which is low in ammonia.

The serum neomycin concentrations measured at intervals after neomycin enemas never exceeded 5μg. per milliliter, with one exception (Fig. 3). This concentration is considerably below those reported in instances in which toxicity from neomycin has been reportedly observed. No evidence of renal tubular damage, "neuromuscular blockade," or ototoxic effect was obtained in any of the animals receiving neomycin enemas.

In another experimental group, consisting of four dogs, two were fed horse meat for three days, while the other two were maintained on a low-protein, meat-free diet. Exploratory laparotomies were then done on all four dogs, and samples of blood were taken from the venous return of their colons for determinations of ammonia. Saline enemas followed by 1% neomycin enemas were given to one of each of the meat-fed

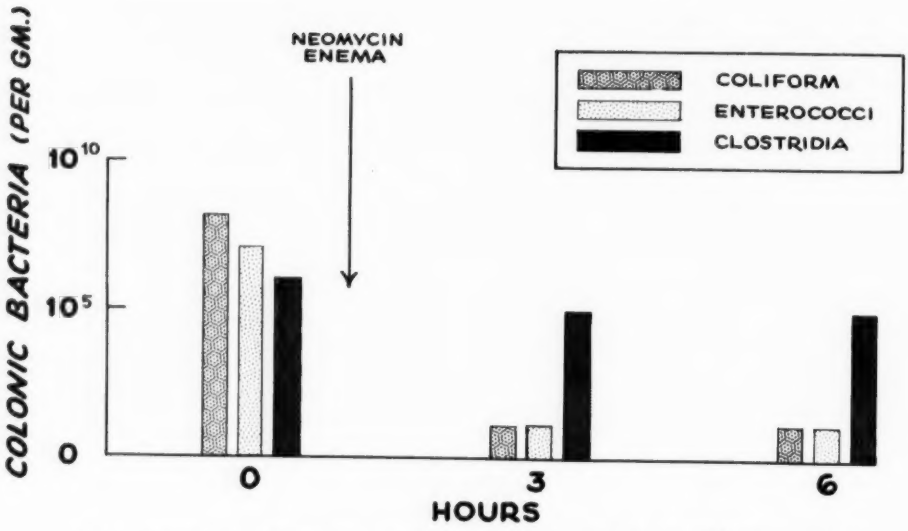


Fig. 1.—Graph indicating the mean of the numbers of bacteria of the coliform, enterococci and clostridia types per gram of stool specimen taken from 10 experimental animals following enemas of 1% neomycin solution.

and non-meat-fed dogs, whereas only saline enemas were given to the other two, corresponding dogs. Samples of the venous return from the colons of all four dogs were obtained every hour for five hours following the administration of the enemas for determination of ammonia. Following neomycin enemas, whether or not the animals were prefed meat, there was an immediate and marked reduction of the ammonia content of venous blood from the colon. This was in contrast to the minimal changes in colonic venous blood ammonia concentrations following saline enemas. The effect of the

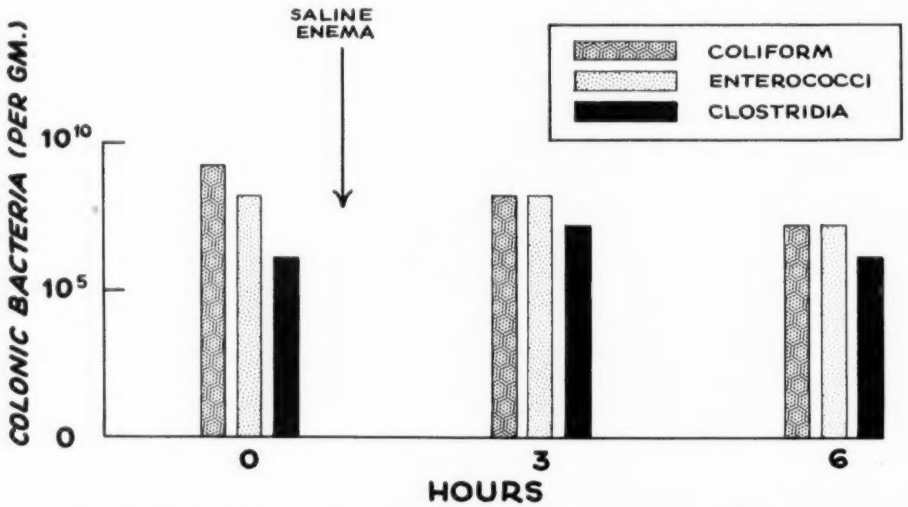


Fig. 2.—Graph showing the bacterial counts of coliform, enterococci, and clostridia organisms from stool specimens of two experimental animals following enemas of saline solution.

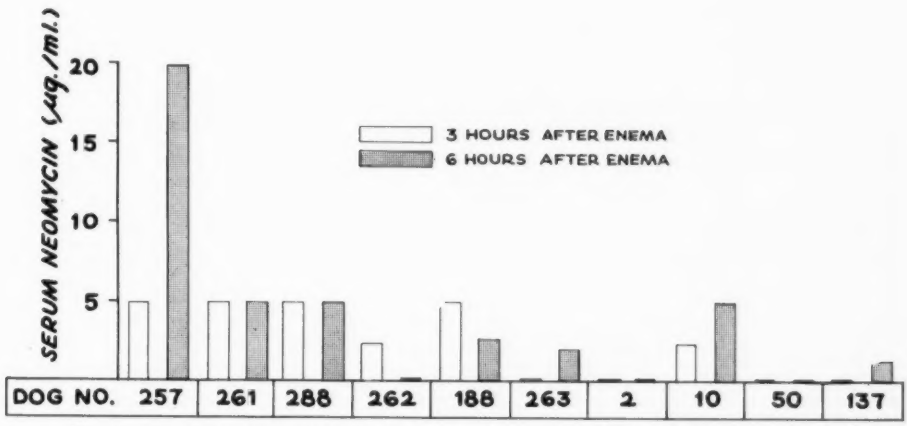


Fig. 3.—Graph showing the blood serum neomycin concentrations in 10 experimental animals three and six hours following enemas of neomycin solution.

neomycin enema on the blood ammonia was, however, more marked when the animals were prefed meat (Figs. 4 and 5).

Neomycin enemas were given to 22 patients with ammonia intoxication and hepatic encephalopathy. These patients were unable to take medications orally, because of upper gastrointestinal hemorrhage, vomiting, or paralytic ileus following surgical operations. In every case a cleansing enema was first given followed by a retention enema of 500 to 700 cc. of a 1% neomycin solu-

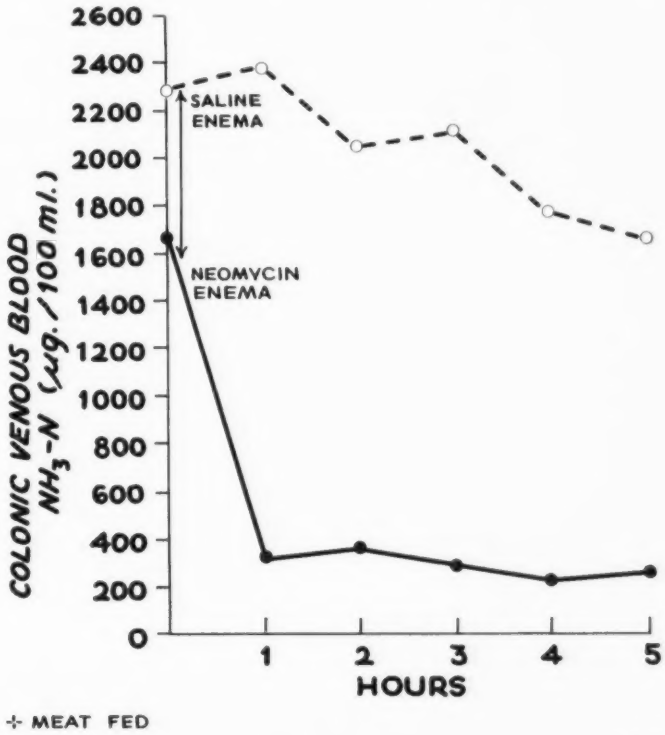


Fig. 4.—Graph comparing the effects of neomycin and isotonic saline enemas on the concentration of ammonia in the venous blood from the colon of dogs fed meat for the preceding three days.

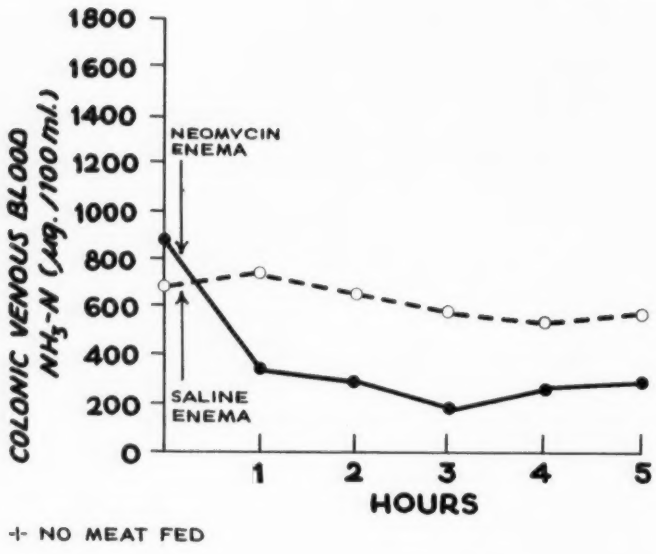


Fig. 5.—Graph comparing the effects of neomycin and isotonic saline enemas on the concentration of ammonia in the venous blood from the colon of dogs that were maintained on a low - protein, meat - free diet for the preceding three days.

tion.† Venous blood ammonia concentrations were obtained before and 6 to 12 hours after the administration of the enemas. The clinical stage of encephalopathy was estimated by the method described by Najarian and Harper.[11]

In every case a marked reduction in peripheral venous blood ammonia concentration occurred within 12 to 24 hours following administration of neomycin enemas. The reduction in the blood ammonia was usually followed by clinical evidence of improvement of the patient. In some cases daily neomycin enemas were given for a week to 10 days. These were sufficiently effective to serve as the only therapeutic measure needed to control the blood ammonia in several patients with portal cirrhosis and gastrointestinal bleeding. No evidence of toxicity from neomycin was observed in any of these patients. The neomycin enemas were discontinued, and the drug was given by mouth as soon as this became feasible.

The following two cases illustrate the ability of neomycin enemas to control ammonia production within the colon.

Report of Cases

CASE 1.—A 49-year-old white man with a long history of portal cirrhosis was admitted to the hospital because of upper gastrointestinal hemorrhage from esophageal varices. After three episodes of bleeding, an end-to-side portacaval anastomosis was done. The blood ammonia concentration on the first postoperative day was 72μg. per 100 ml.

On the 21st postoperative day the patient developed slurred speech, "liver flap," and increased deep tendon reflexes. The blood ammonia was 143μg/100 ml., and the patient became lethargic and eventually stuporous. He was then given a cleansing enema, followed by the instillation of 500 ml. of a 1% solution of neomycin into the rectum. The following morning the blood ammonia had decreased to 96μg/100 ml. The patient's sensorium had cleared, and the "liver flap" had disappeared. By the next day he was completely lucid, with a blood ammonia of 89μg/100 ml., and remained well for several days.

On the 30th postoperative day the blood ammonia was 148μg/100 ml. and the patient was becoming lethargic. A cleansing enema was given, but it was not effective in reducing the blood ammonia concentration. The following morning the blood am-

† The procedure used to fill the colon with the 1% neomycin solution and to assure adequate retention of the solution was as follows: The neomycin enema was introduced first with the patient in the supine position. He was turned to the left lateral decubitus position for 5 minutes, and then to the right lateral decubitus position for another 5 to 10 minutes. The effectiveness of this technique for filling the colon has been confirmed by fluoroscopy during barium-enema x-ray examinations.

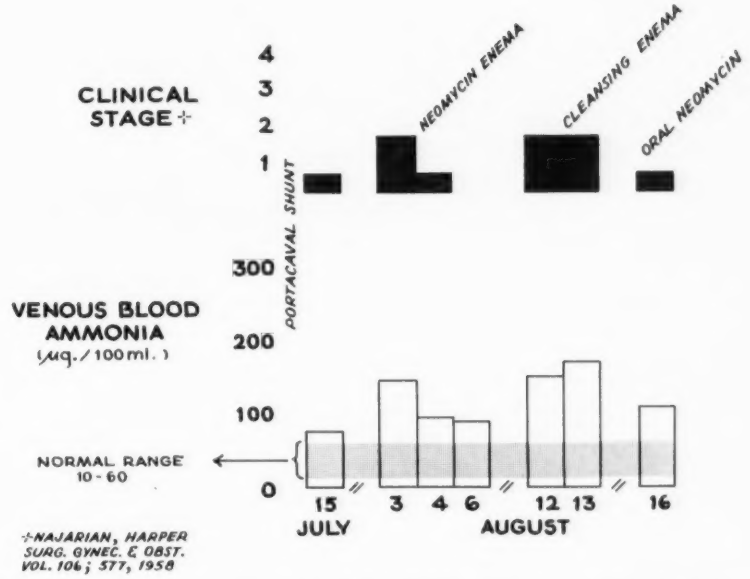


Fig. 6.—Graph comparing the effects of the administration of an enema of 1% neomycin solution, an isotonic saline enema, and orally administered neomycin on the peripheral venous blood ammonia concentrations in a patient who had had a portacaval anastomosis.

monia had increased to 161μg/100 ml., with no change in the clinical status of the patient. At this time the patient could take oral medications, and so it was unnecessary to give neomycin by enema. Therefore neomycin administration was started by mouth, and a gradual decline in the ammonia to 105μg/100 ml. occurred within the next five days, associated with complete clearing of the patient's sensorium (Fig. 6).

Case 2.—A 54-year-old white man, with portal cirrhosis, was admitted to the hospital because of bleeding esophageal varices. He was in a state of stupor with hyperactive deep tendon reflexes and an obvious pronounced "liver flap." Venous blood ammonia concentration was 231μg/100 ml. A Sengstaken tube was passed; gastric lavage was begun, and a cleansing enema was given. The following morning the patient's blood ammonia had increased to 246μg/100 ml., and he was comatose. Fifty grams of arginine was given intravenously each day for the next two days; the blood ammonia decreased to 153μg/100 ml., associated with clearing of the sensorium. On the fourth day the Sengstaken tube was decompressed, and, no further bleeding being evident, the tube was removed. The patient had minimal upper gastrointestinal bleeding two days after removal of the Sengstaken tube, but the blood ammonia rose to 184μg/ml. and the patient again became stuporous. He was unable to take medications orally because of paralytic ileus. On each of three days cleansing enemas, followed by 1% neomycin enemas, were given, and a progressive reduction of blood ammonia concentration associated with clearing of the patient's sensorium occurred. The blood ammonia was simultaneously reduced to 89μg/100 ml. Two days later the blood ammonia increased again to 132μg/100 ml. A cleansing enema was given, resulting in no essential change in the venous blood ammonia. Then a neomycin enema was given, which induced a decrease in the blood ammonia to 84μg/100 ml., and this was associated with gradual clinical improvement. The patient was then started on orally administered neomycin (Fig. 7).

Summary

Neomycin enemas were given to adult mongrel dogs and saline enemas to control dogs. An immediate and sustained reduction in the concentration of ammonia in the venous blood returning from the colon occurred in those animals given neomycin enemas. Coliform bacteria and enterococci were greatly reduced in stool samples examined three hours after neomycin enemas; in contrast, the reduction in the same groups of bacteria in stool specimens taken after saline enemas was insignificant. The concentrations of neomycin in the serum re-

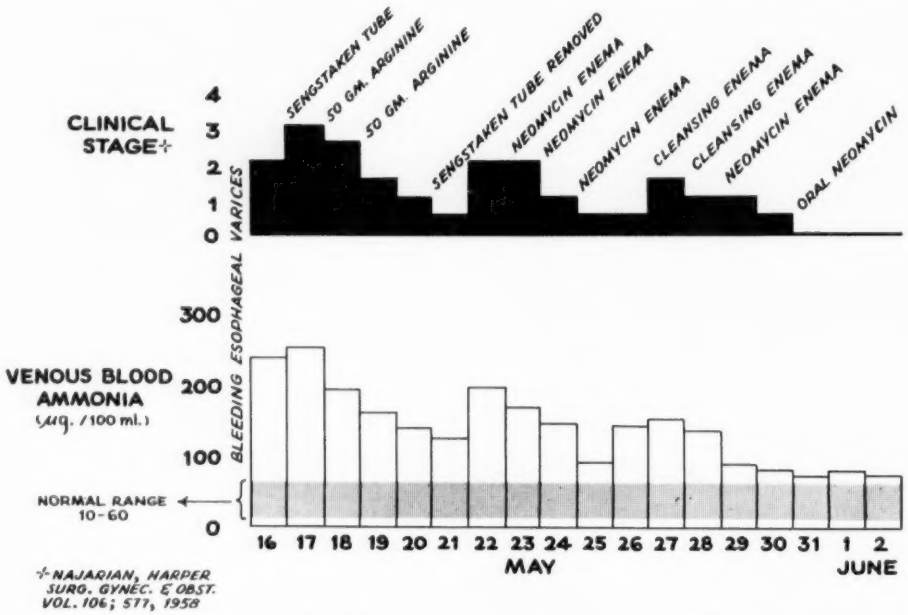


Fig. 7.—Graph comparing the effects of arginine therapy, administration of an enema of 1% neomycin solution, an isotonic saline enema, and orally administered neomycin on the peripheral venous blood ammonia concentrations in a patient with portal cirrhosis and bleeding esophageal varices.

mained low following neomycin enemas, and no toxic effects were observed in any of the animals.

Neomycin enemas given to 22 patients with ammonia intoxication and hepatic encephalopathies produced prompt and consistent reduction in peripheral blood ammonia concentrations and clinical improvement. In contrast, the use of cleansing enemas failed to produce any significant improvement in the biochemical and clinical status of patients with ammonia intoxication.

Dept. of Surgery, University of California School of Medicine.

REFERENCES

1. Folin, O., and Denis, W.: Protein Metabolism from Standpoint of Blood and Tissue Analysis: The Origin and Significance of the Ammonia in the Portal Blood, J. Biol. Chem. 11:161, 1912.

2. Folin, O., and Denis, W.: Protein Metabolism from the Standpoint of Blood and Tissue Analysis: New Methods for the Determination of Total Non-Protein Nitrogen, Urea and Ammonia in the Blood, J. Biol. Chem. 11:527, 1912.

3. McDermott, W. V., Jr. and Adams, R. D.: Episodic Stupor Associated with Eck Fistula in Human with Particular Reference to Metabolism of Ammonia, J. Clin. Invest. 33:1, 1954.

4. Havens, L. L., and Child, C. G., III: Recurrent Psychosis Associated with Liver Disease and Elevated Blood Ammonia, New England J. Med. 252:756, 1955.

5. Silen, W.; Harper, H. A.; Mawdsley, D. L., and Weirich, W. L.: Effect of Antibacterial Agents on Ammonia Production Within the Intestine, Proc. Soc. Exper. Biol. & Med. 88:138, 1955.

6. Fisher, C. J., and Faloon, W. W.: Blood Ammonia Levels in Hepatic Cirrhosis: Their Control by the Oral Administration of Neomycin, New England J. Med. 256:1030, 1957.

7. Dawson, A. M.; McLaren, J., and Sherlock, S.: Neomycin in the Treatment of Hepatic Coma, Lancet 2:1263, 1957.

8. Conway, E. J.: Microdiffusion Analysis and Volumetric Error, Ed. 2, New York, D. Van Nostrand Company, 1950.

9. Grove, D. C., and Randall, W. A.: Assay Methods of Antibiotics: A Laboratory Manual, New York, Interscience Encyclopedia, Inc., 1955.

10. Waksman, S. A.: Neomycin: Its Nature and Practical Application, Baltimore, Williams & Wilkins Company, 1958.

11. Najarian, J. S., and Harper, H. A.: Etiology and Treatment of Ammonia Intoxication Associated with Disease of the Liver, Surg. Gynec. & Obst. 106:577, 1958.

Clinical Use of Intravenous Fat in Surgical Patients

WILLIAM H. MARSHALL, M.D., Chicago

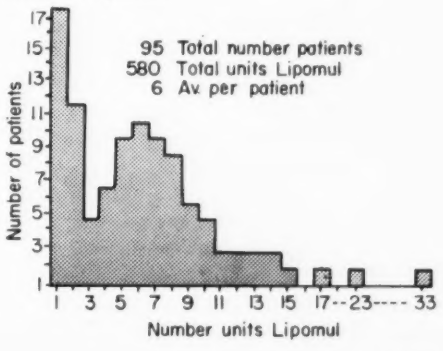
An intravenous fat emulsion (Lipomul I. V.) has recently become available for clinical use. Utilizing a 15% emulsion of cottonseed oil with soybean phosphatides and Pleuronic F-68 (oxyethyleneoxypropylene polymer) as stabilizers, it is prepared with 4% dextrose in water as a vehicle.[1] A preliminary report from the surgical service of the Illinois Research and Educational Hospitals[2] indicated that this improved fat emulsion was sufficiently free of side-effects to make it safe for routine clinical use. The most prominent reactions noted in this study were a transient minor hypertensive response in 48% of infusions and a transient temperature elevation in 1.6% of patients.

Studies on this preparation have since been extended to include an additional 95 patients, who have received a total of 580 units of intravenous fat for an average consumption of 6 units per patient. Each unit contained 500 or 600 cc. of fat emulsion, depending on whether it was given before or after July, 1958, when Lipomul I. V. became commercially available.

All patients in this series were ill and hospitalized, with the vast majority undergoing major surgery. Lipomul was used in almost all cases with intravenous protein hydrolysates and forced oral feedings, where possible, in an effort to improve the status of seriously ill, nutritionally debilitated patients. No patients were eliminated because of the severity of the illness, jaundice, fever, or hypertension. Of the total 95 patients, 63 patients were suffering from carcinoma, 51 having a carcinoma of the gastrointestinal tract, which largely accounted for their severe nutritional deficiency. Twenty-two patients had a measurable impairment of liver function, as evidenced by jaundice or significant abnormality of liver function studies. No difference in tolerance to intravenous fat was noted in these patients as compared with those without liver disease. The majority were in the upper decades of life, 56 of the 95 patients being 60 years or older. The oldest patient given intravenous fat was 82 years of age, and he received 14 units of this substance, and subsequently underwent a Hartman resection for carcinoma of the rectum. Lipomul was given prior to surgery in 61 patients, after surgery in 18 patients, and in both the pre- and postoperative periods in 13 patients.

The Figure indicates the number of units received by each patient. Sixteen patients were given 10 units or more. One patient, receiving 33 units, was suffering from a high jejunal fistula following surgery for carcinoma of the ovary. She was maintained for 36 days almost entirely on intravenous fluids, including protein hydrolysates and Lipomul. The initial total plasma protein

Distribution of number of units of Lipomul I. V. received by patients.



Read at the 66th Annual Meeting of the Western Surgical Association, Rochester, Minn., May 21, 1958.

The fat emulsion used in this series of patients was kindly furnished by The Upjohn Company, Kalamazoo, Mich.

was 5.7 gm. per 100 cc., with a 2.9/2.8 A/G ratio. One week prior to death the total proteins remained at 5.7 gm/100 cc., with a 2.5/3.2 A/G ratio. The autopsy report noted the lack of nutritional debilitation. No evidence of bleeding was seen. The liver was fatty, but not more so than was to be expected, considering the prolonged illness.

Temperatures were taken only at times prescribed by routine ward procedures. Hence an accurate evaluation of minor febrile reactions cannot be made. It is sufficient to state that these minor elevations were not noted by either ward personnel or patients and in no way interfered with the use or usefulness of the fat preparation.

The accompanying Table gives a brief summary of more marked reactions to intravenous fat.

Summary of Reactions to Lipomul

Patient	No. of Reactions	No. of Infusions Received
I. Temperature Elevation Above 102 F.		
1	1	6
2	1	6
3	1	1
4	1	5
Incidence of febrile reactions: 4% of patients; 0.7% of infusions		
II. Other Minor Reactions (Headache, Flushing, Backache)		
5	1	9
6	1	6
4	1	5
Incidence of minor reactions: 3% of patients; 0.5% of infusions		

Of four patients having significant elevations of temperature, two had further infusions on subsequent days without recurrence of symptoms. Twenty patients were running a febrile course during the series of infusions without experiencing difficulty. Of three patients showing symptoms of headache, flushing, or back pain, all had subsequent infusions without difficulty. As previously reported [3] the reactions sustained tended to occur during the first or second infusion and to disappear with subsequent infusions. Many patients experienced subcutaneous infiltrations without pain or discomfort. No sclerosing effect on veins was noted.

A review of patients receiving multiple infusions was made to see whether any increased tendency to bleeding episodes could be detected. Five patients who had received from 8 to 17 units of Lipomul showed evidence of hemorrhage during or immediately subsequent to a series of infusions. Sufficient cause for hemorrhagic episodes (e. g., gastric ulcer, ulcerative colitis, toxic granulocytopenia) could explain the bleeding in all but one case. A summary of this case is outlined below.

A 67-year-old white man was admitted to Research Hospitals with a duodenal-stump fistula of 12 months' duration following a cholecystectomy. Six years previously he had undergone a successful subtotal gastric resection for carcinoma of the stomach. During the year prior to admission the clinical course had resulted in severe malnutrition.

Laboratory values on admission were as follows: total serum proteins 7.4 mg. %; A/G ratio 4.4/3.8; NPN 33 mg. %; sulfobromophthalein (BSP) retention 24.8%; thymol turbidity 2.1 units; cephalin flocculation negative; alkaline phosphatase 5.4 units; clotting time seven minutes.

In an effort to improve the nutritional status, a high-calory, high-protein diet with supplementary tube feeding, protein hydrolysates, and Lipomul intravenously were given and resulted in a 10-lb. weight gain in the subsequent nine-day period. A successful closure of the fistula was performed, after which the patient continued to receive fat emulsion and protein hydrolysates during the early postoperative period.

On the fifth day following the 17th, and final, unit of Lipomul, the onset of lethargy was noted, associated with a rising blood nonprotein nitrogen. Two days later petechiae, dark tarry stools, epistaxis, and a serosanguineous wound drainage were noted. A rapid fall in the hematocrit from 45% to 31% occurred. No hepatosplenomegaly was detected. The temperature was elevated, running from 102 to 103 F orally.

Laboratory reevaluation revealed that NPN was 60 mg. %, prothrombin time 85.5%, clotting time 12 minutes, bleeding time 3.5 minutes, and platelet count 200,000 per cubic millimeter. A Rumpel-Leede test was negative. Hematology consultation was obtained and suggested the possibility of an allergic purpura. Other medications, including prochlorperazine (Compazine), sulfamethoxypyridazine (Kynex), tolbutamide (Orinase), and quinidine, were discontinued, with prompt disappearance of hematologic findings and recovery.

Autopsies were performed on 16 patients who had received from 1 to 33 units of Lipomul. The interval between the last unit of Lipomul and autopsy varied from 1 to 21 days. Findings which might possibly be related to Lipomul included brown pigment granules in the reticuloendothelial system of the spleen. This was noted in six cases. Similar brown pigment was noted in the Kupffer cells of the liver in five cases. Fatty changes in the liver were noted in five cases; however, this was felt to be no more than the usual amount seen in severely ill patients coming to autopsy.

Comment

The need for a high-calory, low-volume intravenous nutritional supplement in pre- and postoperative care is attested to by many writers.[4-7] It has been repeatedly demonstrated that intravenous fat emulsions provide such a supplement. Numerous studies demonstrate the fact that intravenous fat is as efficiently metabolized as oral fat [8] and has a powerful protein-sparing effect in both well and sick persons.[9-11]

Early attempts to utilize intravenous fat emulsions were accompanied by too high an incidence and severity of side-reactions to permit their clinical use.[12,13] However, the improved emulsion used in this and other studies has been shown to be sufficiently free of reactions to permit its unrestricted clinical use.[14]

The reported incidence of minor febrile reactions varies from 2% to 30%, depending probably upon the closeness with which the temperature is followed during and after infusion.[1,15,16] The cause of the temperature elevation is unknown, but is felt to be related either to metabolic heat produced by the fat or to pyrogenic reactions.[17,18] In support of the former is the fact that temperature seems to be related to the speed of clearance of fat from the blood stream, as measured by serum turbidity studies.[15,17] The majority of febrile reactions are unnoticed by the patients and do not constitute a significant contraindication to the clinical use of intravenous fat.

A transient, but significant, elevation of sulfobromophthalein (Bromsulphalein) retention following a series of infusions has been described by Preston and associates.[18] Minor and less constant elevations of the thymol turbidity and cephalin flocculation tests were also noted by this group. However, liver function tests return to normal after completion of a series of infusions. As noted in the present series, hepatic disease does not contraindicate the use of or increase the number or severity of reactions to intravenous fat. In fact, it has been demonstrated that plasma is cleared more rapidly of fat in patients with advanced cirrhosis.[19]

Autopsies have failed to show significant lesions in patients receiving fat emulsions.[18,20] The brown pigment in the spleen and Kupffer cells of the liver is a common finding. Thompson et al.[21] have studied the histochemical characteristics of this pigment and feel it is a pigment-lipid complex which is unique in animals and patients receiving intravenous fat. They propose that it be termed "intravenous fat pigment." The fatty infiltrations of the liver are probably related to the patient's primary disease rather than to the administration of fat emulsions. Studies on animals indicate that fat stores in persons maintained on intravenous fats have different saponification and iodine number characteristics than does the infused fat, and hence do not represent mere deposition of infused fat.[22,23]

The only significant toxic reaction related to intravenous fat is a bleeding diathesis, which has been seen only in patients receiving 15 or more units of fat.[24-26] It is characterized by fever, lethargy, epistaxis, petechiae, gastrointestinal bleeding, hepatosplenomegaly, progressive anemia, prolongation of clotting time, and a decrease in prothrombin time. Mueller reports a case with a rapid subsidence of symptoms on the administration of hydrocortisone. This led him to suggest a hypersensitive mechanism. The exact incidence of the reaction is unknown, but, in view of the few cases reported, it must be rare. It is felt that the

case included in this study may be an example of hemorrhagic diathesis secondary to Lipomul. However, other drugs may have been implicated. Until more is known of this reaction, it seems advisable to limit the number of infusions to 14 per patient.

Summary

A study of 95 surgical patients receiving 580 units of Lipomul I. V. demonstrates the relative freedom of the drug from side-effects. Minor reactions, autopsy studies, and one possible instance of a severer toxic reaction are discussed. It is felt that Lipomul I. V. represents an important advance in the pre- and postoperative care of nutritionally debilitated surgical patients and is safe for routine clinical use.

Dept. of Surgery, University of Illinois College of Medicine, 840 S. Wood St.

REFERENCES

1. Meyer, C. E.; Fancher, P. E.; Schurr, P. E.; Webster, H. D.: Composition, Preparation and Testing of an Intravenous Fat Emulsion, Metabolism 6:591, 1957.

2. Smith, M. E.: Clinical Studies on Intravenous Fat, Metabolism 6:717, 1957.

3. Jordan, P. H., Jr.: Intravenous Administration of an Improved Fat Emulsion, Metabolism 6:656, 1957.

4. Schneewind, J. H.: Intensive Preoperative Nutritional Therapy, Surgery 44:424, 1958.

5. Schneewind, J. H.: Precautions in Determining Operability as Related to Nutrition, S. Clin. North America 38:31, 1958.

6. Ellison, E. H.; McCleery, R. S.; Zollinger, R. M., and Case, C. T.: Influence of Caloric Intake upon the Fate of Parenteral Nitrogen, Surgery 26:374, 1949.

7. Rice, C. O.; Orr, B.; Treloar, A. E., and Strickler, J. H.: Parenteral Nutrition in Surgery: Significance of Calories and Protein in Maintaining Positive Nitrogen Balance, Arch. Surg. 61:977, 1950.

8. Bentley, W. B., and Van Itallie, T. B.: Metabolic Effects of Fat Emulsions Administered Intravenously to Human Subjects, J. Lab & Clin. Med. 48:184, 1956.

9. Krieger, H.; Abbott, W. E.; Levey, S., and Holden, W. D.: The Use of a Fat Emulsion as a Source of Calories in Patients Requiring Intravenous Alimentation, Gastroenterology 33:807, 1957.

10. Artz, C. P., and Williams, T. K.: Intravenous Fat as Supportive Therapy After Severe Injuries, Am. J. Surg. 95:651, 1958.

11. Van Itallie, T. B.; Moore, F. D.; Geyer, R. P., and Stare, F. J.: Will Fat Emulsion Given Intravenously Promote Protein Synthesis? Metabolic Studies on Normal Subjects and Surgical Patients, Surgery 36:720, 1954.

12. Collins, H. S.; Kraft, L. M.; Kinney, T. D.; Davidson, C. S.; Young, J., and Stare, F. J.: Parenteral Nutrition: III. Studies on the Tolerance of Dogs to Intravenous Fat Emulsions, J. Lab. & Clin Med. 33:143, 1948.

13. McKibbin, J. M.; Pope, A.; Thayer, S.; Ferry, R. M., Jr., and Stare, F. J.: Parenteral Nutrition: I. Studies on Fat Emulsions for Intravenous Alimentation, J. Lab. & Clin. Med. 30:488, 1945.

14. Cole, W. H.: Fat Emulsion for Intravenous Use, Guest Editorial, J. A. M. A. 166:1042, 1958.

15. Forbes, A. L.: Incidence of Reactions to Intravenous Fat Emulsion Administered at Two Different Rates, Metabolism 6:645, 1957.

16. Mueller, J. F.: Experiences in Human Beings with an Improved Fat Emulsion for Intravenous Administration, J. Lab. & Clin. Med. 50:267, 1957.

17. Mueller, J. F.: Studies on the Phenomenon of Clearing of Infused Fat Emulsions from Human Blood and Its Relationship to Febrile Reactions, J. Lab. & Clin. Med. 50:267, 1957.

18. Gates, J. M.; Barnes, A. U.; Henegar, G. C., and Preston, F. W.: The Effect of an Intravenous Fat Emulsion on Liver Function, A. M. A. Arch. Surg. 77:336, 1958.

19. Cutin, J., and Kern, F., Jr.: Plasma Clearance of Induced Hyperlipemia in Hepatic Disease, Clin. Res. 6:58, 1958.

20. Bozian, R. C.; Davidson, N. W.; Stutman, L. J., and Wilkinson, C. F., Jr.: Observations on the Use of Intravenous Fat Emulsions in Man, Metabolism 6:703, 1957.

21. Thompson, S. W.; Johnson, F. B., and Forbes, A. L.: Staining Characteristics of a Pigment Associated with Intravenous Fat Alimentation, Lab. Invest. 7:533, 1958.

22. McKibbin, J. M.; Ferry, R. M., Jr., and Stare, F. J.: Parenteral Nutrition: II. The Utilization of Emulsified Fat Given Intravenously, J. Clin. Invest. 25:679, 1946.

23. Lerner, S. R.; Chaikoff, I. L., and Entenman, C.: Fate of C^{14}-Labeled Palmitic Acid Administered Intravenously as a Tripalmatin Emulsion, Proc. Soc. Exper. Biol. & Med. 70:384, 1949.

24. Mueller, J. F.: Recent Advances in Intravenous Fat Alimentation, Am. J. Clin. Nutrition 6: 472, 1958.

25. Levenson, S. M.; Upjohn, H. L., and Sheely, T. W.: Two Severe Reactions Following the Long-Term Infusion of Large Amounts of Intravenous Fat Emulsion, Metabolism 6:807, 1957.

26. Watkin, D. M.: Clinical, Chemical, Hematologic and Anatomic Changes Accompanying Repeated Intravenous Administration of Fat Emulsion to Man, Metabolism 36:785, 1957.

DISCUSSION

DR. FREDERICK W. PRESTON, Chicago: At the Veterans Administration Research Hospital in Chicago we have been interested in defining the limitations of intravenous fat infusions, with particular reference to their use in patients who must be fed by vein for many consecutive days. Dr. Joseph A. Werr gave 21 daily infusions of 500 ml. of Lipomul I. V. to 20 hospitalized patients. Blood coagulation was studied by means of six clotting tests before, during, and after the infusions (*Clin. Res.* 6:395, 1958). All patients developed one or more coagulation defects, and three had sufficient hemorrhage to cause shock and require transfusions. At the time of hemorrhage there was hypocoagulability of the blood. In each case the hemorrhages occurred after two weeks or more of daily infusions. A patient who is given daily infusions for more than 14 consecutive days should be watched carefully for evidence of hypocoagulability, and if this occurs the infusions should be discontinued.

DR. JOHN H. OLWIN, Chicago: The bleeding complications in this type of infusion, I think, are of interest, and certainly are of importance. Dr. Preston tells me that there is in this material a soybean phosphatide, and that as the concentration of soybean phosphatide increases, the reactions tend to become severer. There is in the soybean phosphatide a substance which we call phosphatidylethanolamine, which we believe to be the active coagulation principle that platelets supply. If this material is allowed to interact with certain factors in the blood, namely antihemophilic globulin, a plasma component which we call PTC, and AC globulin, there is formed what we call intrinsic or blood thromboplastin.

The possibility suggests itself that the same condition might occur here which we see in certain types of obstetrical pathology, namely, premature separation of the placenta, retained dead fetus, and amniotic embolism, in which condition as you know, there may occur serious, and sometimes fatal, hemorrhage. This is on the basis of a gradual defibrination of the blood.

Earlier this month I discussed a paper on this subject that Dr. Preston read before the Chicago Surgical Society, and I suggested that this might be a similar type of pathology developing; but he tells me this morning that he has since assayed the fibrinogen levels on a number of his patients, and they are all normal, so that somewhat deflates that theory.

There is one other possibility, and that is that over a period of time there may develop an antithromboplastin in these patients. We believe that the bleeding tendency in hemophilia is not necessarily caused by a deficiency of antihemophilic globulin only but is due also to an excess of antithromboplastin.

DR. WILLIAM MARSHALL, Chicago: I would like to thank Dr. Preston and Dr. Olwin for their comments. We have not had an opportunity to study the possibility of coagulation defects associated with multiple infusions.

Temporary Exclusion of Liver from the Circulatory System

Method for Metabolic Studies in Animals

RICHARD L. DAKIN, M.D.; JACK JEW, M.D.; HAROLD A. HARPER, Ph.D., and H. J. McCORKLE, M.D., San Francisco

Evidence for the specific contribution of the liver to a metabolic process has in the past been obtained by studies in animals after total hepatectomy. Because the physiological status of the animal is progressively impaired following hepatectomy, it seems desirable to utilize a procedure whereby the blood supply might be temporarily excluded from and then returned to the liver. The subsequent survival of the animal would then indicate the viability of the extrahepatic tissues during the period of isolation of the liver from its vascular supply. Under these circumstances the hepatic contribution to the metabolism of a given substance could be evaluated by a comparison of its utilization before, during, and after exclusion of the liver from the circulatory system.

Mann,[1] in 1921, described a three-stage procedure for total removal of the liver. In the first stage of his procedure a side-to-side portacaval anastomosis was made, followed by ligation of the inferior vena cava proximal to the anastomosis. After waiting three to four weeks to allow development of collateral circulation through the azygos system, a second laparotomy was performed, and the portal vein was ligated proximal to the portacaval anastomosis to divert the portal blood into the vena cava and the previously established collateral venous channels. Finally, at a third operation, the liver was removed. Firor and Stinson,[2] in 1929, developed a procedure for a single-stage hepatectomy in the dog, using a Y-shaped glass cannula to connect the distal portal vein and the prehepatic vena cava with the posthepatic vena cava. Markowitz et al.[3] modified this operation by using a side-to-side portacaval anastomosis to divert the portal blood into the prehepatic vena cava and a glass tube to connect the pre- and posthepatic parts of the vena cava. Leveen and Lewis,[4] in the description of their method for total hepatectomy, have suggested the use of a Y-shaped plastic tube, which may be clamped during its introduction into the veins, thus lessening the dangers of severe hemorrhage and air embolization, which were significant risks in the previously described procedures. Lichtenstein et al.[5] have recently described a method for temporary exclusion of the circulation from the liver in the dog in which also a Y-shaped plastic tube is used to convey the portal and vena caval blood streams past the liver. In our experience with Lichtenstein's method, the return of the circulation to the liver was difficult and slow because of the precautions necessary to avoid injury to the thin-walled portal vein. Furthermore, clotting within the plastic tube occurred within the first 24 hours.

The following method for temporary exclusion of the liver from the circulation in the dog permits immediate transition of the liver to and from the vascularized state,

Read at the 66th Annual Meeting of the Western Surgical Association, Rochester, Minn., Nov. 21, 1958.

From the Surgical Research Laboratories and the Department of Surgery of the University of California School of Medicine.

Supported by a grant from the National Institute for Arthritis and Metabolic Diseases, USPHS A-1053, and the Christine Breon Fund for Medical Research.

without the creation of a permanent portacaval shunt. The polyethylene tube used for hepatic exclusion is later removed, thereby greatly reducing the possibility of clot formation, which otherwise limits the survival of the animal during the immediate postoperative period.

Method

The animal is anesthetized with intravenous pentobarbital sodium and placed on its left side. A long incision is made in the right ninth intercostal space, from the paravertebral musculature to the linea alba. The pleural cavity is opened, and the diaphragm is incised, giving access to the peritoneal cavity. The right hepatorenal ligament, identifiable as a thin band of peritoneum, is divided, and the prehepatic part of the vena cava is mobilized from the right renal vein to the liver. The right lumboadrenal vein is ligated and divided at its junction with the vena cava. The portal vein is mobilized from the junction of the cranial (superior) and caudal (inferior) mesenteric veins to its entrance into the liver. The gastrosplenic vein is then ligated and divided where it enters the portal vein. The posthepatic part of the vena cava is mobilized for 2 cm. above the diaphragm. Umbilical tapes are placed around the portal vein and the pre- and posthepatic parts of the inferior vena cava. An incision 1 to 1.5 cm. long is then made in the inferior vena cava between two umbilical tapes 1 to 1.5 cm. distal to the liver. A polyethylene tube, 10 cm. long and 1 cm. in diameter, filled with isotonic saline and heparin and clamped at one end, is inserted through the venotomy into the intrahepatic part of the vena cava, until its proximal end lies within the intrathoracic part of the vena cava, 1 to 2 cm. above the diaphragm. A similar venotomy is made in the adjacent wall of the portal vein, and a side-to-side portacaval anastomosis is completed. The hepatic artery is identified from where it crosses deep to the portal vein to the

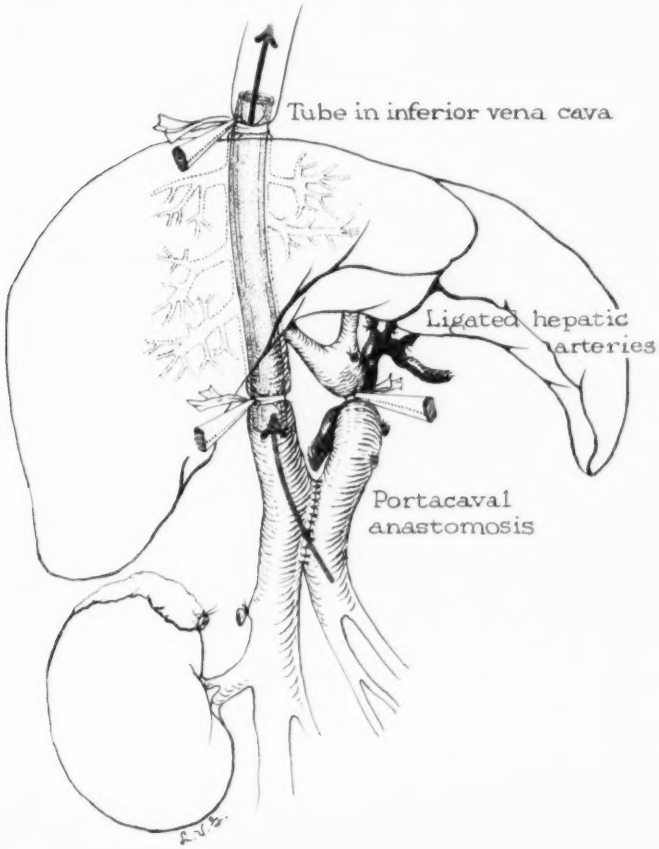


Fig. 1.—Diagram indicating method for exclusion of the circulation from the liver. The polyethylene tube has been placed within the intrahepatic vena cava. The portacaval anastomosis has been completed. The portal vein and branches of the hepatic artery have been occluded, and portal vein blood has been diverted into the vena cava. The tapes around the polyethylene tube have been tightened to isolate the hepatic veins from the vena cava.

origin of the gastroduodenal artery. From this part of the hepatic artery two to five small branches, the hepatic arteries proper, extend cephalad toward the liver. Each branch is occluded with a tape, thus preventing retrograde flow of blood from the gastroduodenal artery into the hepatic arterial system. The portal vein is occluded with an umbilical tape, diverting the portal blood into the inferior vena cava by way of the portacaval anastomosis. Finally, the inferior vena cava is tied down against the indwelling polyethylene tube by the tapes previously placed around the vein, thus completing the exclusion of the liver from the general circulation (Fig. 1).

The circulation can be restored to the liver simply by releasing the temporary ligatures from the inflow and outflow vessels and occluding the portacaval anastomosis. The latter is accomplished by sliding the polyethylene tube distally within the vena cava and tying it in place above and below the portacaval anastomosis (Fig. 2). At the conclusion of the experiment, the polyethylene tube is removed through a new venotomy; this incision and the portacaval anastomosis are closed with continuous sutures of 00000 arterial silk (Fig. 3). The diaphragmatic and thoracotomy incisions are then closed. A wide-spectrum antibiotic, such as tetracycline, is given for several days to inhibit the growth of anaerobic organisms in the temporarily anoxic liver.

Results

Adult mongrel dogs, weighing 10 to 15 kg., were used in these experiments. Temporary exclusion of the hepatic blood supply was done as described, and maintained for periods varying from 20 to 60 minutes. No animal survived hepatic exclusion for longer than 40 minutes. One animal given only a single dose of an antibiotic survived the immediate postoperative period but died on the third postoperative day, with multiple small areas of hepatic necrosis. When the liver was excluded from the circulation for periods up to 40 minutes and adequate antibiotic therapy was used, it was possible to return the circulation to the liver and

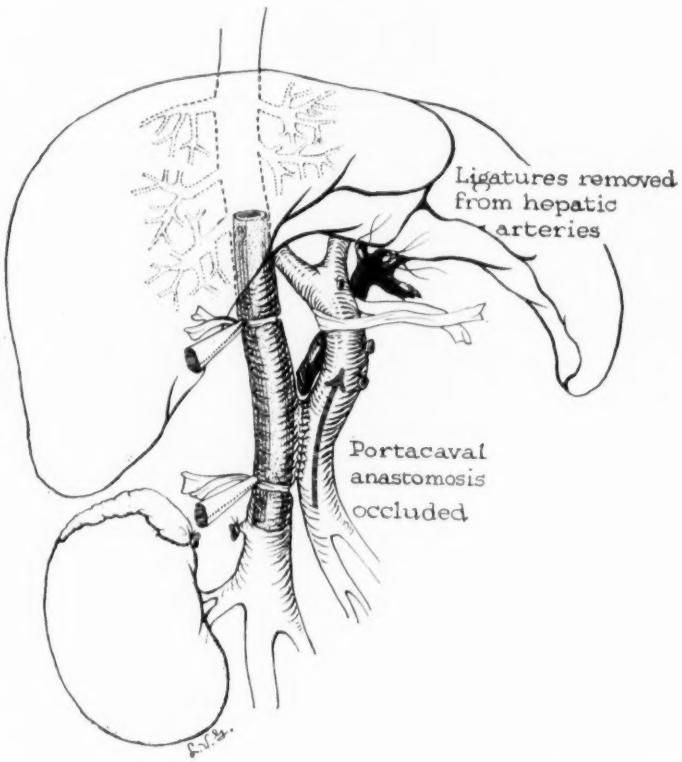


Fig. 2.—Diagram indicating method for restoration of normal hepatic blood flow. The ligatures occluding the inflow and outflow vessels have been released, and the polyethylene tube has been slid distally to occlude the portacaval anastomosis.

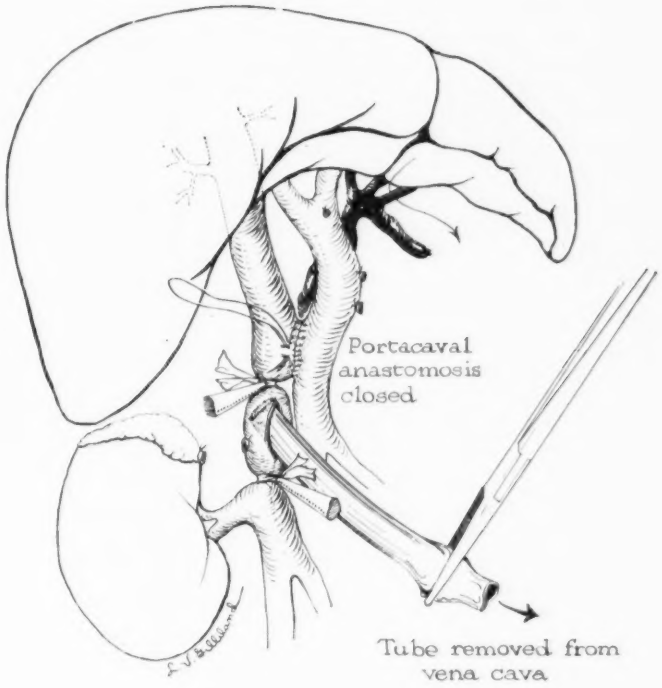


Fig. 3.—Diagram indicating method for removing plastic tube from the vena cava and closure of the portacaval anastomosis.

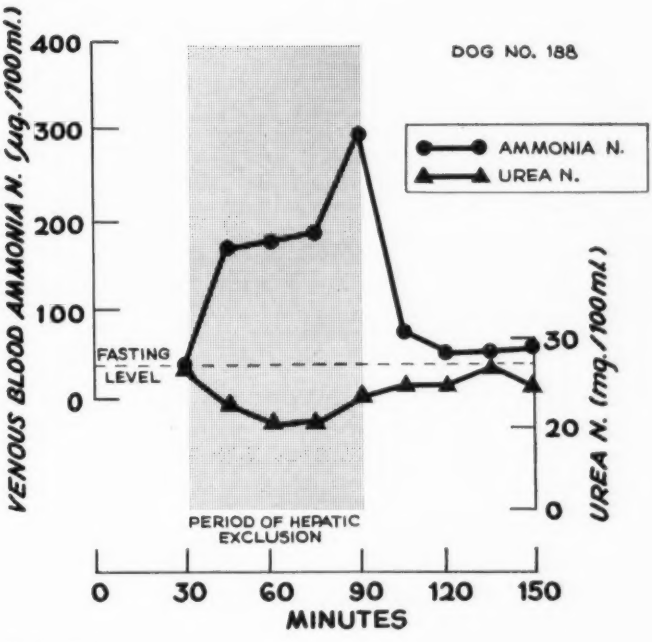


Fig. 4.—Diagram showing effect of temporary exclusion of the hepatic blood supply on ammonia and urea nitrogen in the blood.

have the animal survive for an indefinite period. For example, one animal, in which temporary isolation of the liver from its vascular supply was maintained for 30 minutes, has survived five months. Two others, in which exclusion of the hepatic blood supply was maintained for 40 minutes, are living and apparently well four months following the experiment. Histologic examination of liver biopsy specimens taken from the animals four to six weeks after temporary isolation of the liver from the circulation shows normal hepatic parenchyma.

In animals previously fed a high-protein kennel diet, the concentration of ammonia [6] in the peripheral blood increased rapidly, and the blood urea diminished during the period of exclusion of the liver from the circulation; the values for both returned promptly to normal when circulation was restored (Fig. 4). The blood glucose decreased slightly when the circulation was excluded from the liver, and increased to approximately double that of the fasting concentration when hepatic function was restored (Fig. 5). Although the changes in blood pH as a result of exclusion of the liver from the circulation were inconsistent, there was a tendency for the pH to fall, in some cases as low as 7.2. The serum sodium, potassium, chloride, and carbon

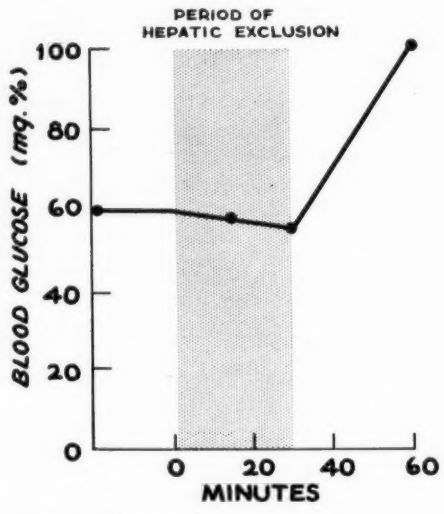


Fig. 5.—Diagram showing effect of temporary exclusion of the hepatic blood supply on the glucose in the blood.

Blood Glucose and Serum Electrolytes During Temporary Exclusion of Liver from Its Bloody Supply

Dog No.	Time in Min.	Glucose Mg/100 Ml.	Sodium mEq/L.	Potassium mEq/L.	CO_2 Content mEq/L.	Chloride mEq/L.	pH
111	(Fasting, preexclusion)	..	159.3	2.76	18.3	95.5	..
	0		Liver excluded from circulation				
	20	..	159.1	2.90	18.1	86.8	..
	30	..	159.4	2.36	21.8	97.2	..
	32		Liver returned to circulation				
	60	..	159.3	2.70	16.7	85.1	..
	90	..	159.4	2.89	21.1	86.8	..
	150	..	..	..	..	..	..
198	(Fasting, preexclusion)	61	..	3.99	21.3	..	7.45
	0		Liver excluded from circulation				
	15	58	..	2.90	20.4	..	7.2
	30	55	..	3.05	22.0	..	7.4
	32		Liver returned to circulation				
	60	102	..	2.63	23.7	..	7.3
	90	..	..	3.35	22.0	..	7.3
152	(Fasting, preexclusion)	..	..	3.96	20.6	..	7.45
	0		Liver excluded from circulation				
	20	..	..	3.16	17.3	..	7.55
	45	..	..	3.72	19.8	..	7.4
	60	..	..	3.64	19.7	..	7.5
	65		Liver returned to circulation				
	90	..	..	2.70	18.4	..	7.4
	120	..	..	3.03	19.8	..	..
	210	..	..	2.89	..	..	..

dioxide content were not significantly altered (Table).

A continuous electrocardiographic tracing and a record of arterial and venous pressures were obtained by means of a recording oscillograph during the procedure. No significant changes were observed.

Summary

A method for producing a temporary exclusion of the liver from its blood supply is described. Using this procedure, it was possible to exclude the liver from the circulation for periods up to 40 minutes, with survival of the animals for an indefinite period.

During temporary exclusion of the hepatic circulation, the peripheral blood ammonia concentration increased and the blood urea decreased. Both returned promptly to normal when the circulation was returned to the liver. The blood glucose decreased during the procedure but increased markedly as soon as the liver circulation was restored. During the same period no significant changes in blood electrolytes were observed. The blood pressure was maintained throughout the procedure. Liver biopsy tissue from animals surviving the procedure revealed normal hepatic structure.

Dept. of Surgery, University of California School of Medicine.

REFERENCES

1. Mann, F. C.: Studies in the Physiology of the Liver: I. Technic and General Effects of Removal, Am. J. M. Sc. 161:37, 1921.
2. Firor, W. M., and Stinson, E., Jr.: Total Extirpation of Dog's Liver in One Stage, Bull. Johns Hopkins Hosp. 44:138, 1929.
3. Markowitz, J.; Yater, W. M., and Burrows, W. H.: A Simple One-Stage Technic for Hepatectomy in the Dog, J. Lab. & Clin. Med. 18:1271, 1933.
4. Leveen, H. H., and Lewis, L.: A Simplified One-Stage Hepatectomy for Experimental Surgery, Ann. Surg. 139:195, 1954.
5. Lichtenstein, I. L.; Drapkin, H., and State, D.: A Technique for the Reversible Exclusion of the Liver in Dogs, Surgery 40:503, 1956.
6. Conway, E. J.: Microdiffusion Analysis and Volumetric Error, Ed. 2, New York, D. Van Nostrand & Company, 1950.

DISCUSSION

DR. JOHN GRINDLAY, Rochester, Minn.: I would like merely to compliment Dr. Dakin and his associates in this experimental work. Dr. McCorkle has always been one to stimulate young men associated with him to do good research and to report it well.

DR. FREDERICK W. TAYLOR, Indianapolis: Did the artery reopen after release, or did it become thrombosed after the 40 minutes?

DR. RICHARD L. DAKIN, San Francisco: No, sir. It was pulsatile, and there appeared to be a flow through the terminal branches. Some two months after these procedures we took liver biopsy specimens, and these were reported as showing normal hepatic parenchyma.

DR. JACOB K. BERMAN, Indianapolis: I think this is a very good piece of work, and a very ingenious method.

DR. RICHARD L. DAKIN, San Francisco: I wish simply to thank the members of the Association for the privilege of being here today.

In Vitro Incorporation of Rb^{86} by the Erythrocyte as an Index of Intracellular Potassium

GEORGE C. HENEGAR, M.D.; ROGER W. FRISKEY, M.D., and FREDERICK W. PRESTON, M.D., Chicago

A potassium deficiency results when a patient is maintained on parenteral feedings with an inadequate replacement of the potassium ion. This deficiency is severer when the patient has a marked loss of gastrointestinal fluid through suction, fistula, or diarrhea. The deficiency may be increased further by the stress response to surgery, which is known to increase the rate of urinary excretion of potassium. As a compensating factor, the homeostatic mechanisms tend to maintain a normal level of potassium in the extracellular water at the expense of the intracellular potassium; but when the loss has continued for a sufficient length of time, the patient develops metabolic alkalosis.[11,22]

The methods usually used to measure potassium give an estimate of the quantity in the extracellular space only. This extracellular space represents only 5% of the total body potassium pool.[9,11,15,17,18,22,29] Obviously, there is need for an efficient method of measuring intracellular potassium. Therefore, a number of methods have been devised to measure the total body potassium or intracellular pool. One method is the potassium exchange of intracellular potassium, which uses radioactive potassium.[1-3,7] Another method uses stable rubidium as a modification of the potassium exchange method.[4] Both methods have considerable value, but they are limited in usefulness because at least 24 hours is required to set up the necessary equilibrium. More recent studies indicate that a better measurement is obtained in 36 hours.[5,8,23] Since so much time is required, a method has been devised for measuring the incorporation of K^{42} by the human erythrocyte in vivo. This method measures the incorporation of this isotope directly by the red blood cell within two hours.[15] However, the short physical half-life of K^{42} (12.4 hours) makes this isotope impractical for anything but investigative work. In addition, K^{42} is a strong emitter of beta and gamma energy; this makes repeated studies in any one subject hazardous.

The defects in the exchange methods led to the investigation of another method, involving the use of radioactive rubidium (Rb^{86}) for the evaluation of intracellular potassium. Rubidium has been shown to behave like potassium in regard to its transport across the cell membrane.[6,16,19,20,24,26] The isotope Rb^{86} has a half-life of 19.5 days. This isotope also has a strong beta and gamma emission; therefore it can be measured easily. The method reported in this paper is one that is carried out in vitro with incubation of the blood with the isotope Rb^{86}. Reproducible results were obtained in two hours of incubation.

Methods

In all experiments the Rb^{86} of high specific activity is diluted with 0.85% sodium chloride solution so that 2 μc. is contained in 0.1 ml. of solution. A standard solution is made up with 0.1 ml. of the stock solution, containing 2μc. of Rb^{86}, added to 5 ml. of 0.85% sodium chloride solution.

Read at the 66th Annual Meeting of the Western Surgical Association, Rochester, Minn., Nov. 21, 1958.

Supported by grants-in-aid from the Abbott Laboratories and the U. S. Public Health Service (Grant No. A-2354).

From the Departments of Medicine and Surgery, Northwestern University Medical School, and the Department of Surgery, Veterans Administration Research Hospital.

Blood is placed into tubes containing heparin and inverted 20 times to assure thorough mixing. Five milliliters of this whole blood is transferred to a 25 ml. Erlenmeyer flask by means of a volumetric pipette. One-tenth milliliter of the isotope solution, containing 2μc. of Rb^{86} is added with a micropipette. The blood and the isotope are mixed well, and the flask is incubated in a water-bath shaker for two hours. The timing is precise and is started as soon as the blood and isotope are mixed. At the end of the two hours the sample is removed from the water bath, poured into a small test tube, and centrifuged for 10 minutes at 5,000 rpm to separate the plasma; then 1 ml. of this plasma is placed in a plastic counting vial. The counts of radioactivity are carried out in a well scintillation counter.

At the same time, an erythrocyte count and hemoglobin and hematocrit determinations are made. In addition, sodium serum and potassium studies are made by means of a Coleman (Model-21) flame photometer.

The standard solution is counted at the same time as the plasma sample, thus correcting for decay.

The calculation for per cent incorporation of the Rb^{86} by the erythrocyte is done in the following way:

The hematocrit value is corrected for mean corpuscular volume.

$$H=\left(\frac{MCVi=(85)}{MCVf}\right)Hf$$

When H is the corrected hematocrit, Hf is the hematocrit value found, $MCVi$ is the arbitrary ideal mean corpuscular volume (in these calculations it is 85), and $MCVf$ is the mean corpuscular volume found.

Using the corrected hematocrit in the following three equations, we calculate the per cent of administered Rb^{86} incorporated by the erythrocytes in the sample.

$$T-P=R \qquad (1)$$

where T is the total counts added (counts per minute per milliliter in the standard sample times the 5 ml. volume), P is the counts per minute per milliliter in the plasma times the plasma volume in the sample, and R, then, is the counts in the red cell mass in the sample studied.

$$R/T=U \qquad (2)$$

where U represents the per cent uptake by the red blood cells, uncorrected for the packed cell volume.

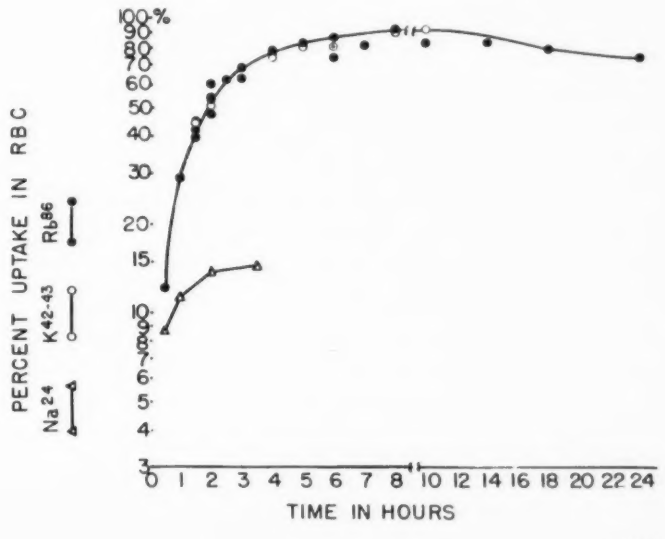
$$U/H=\frac{X}{.47}, \text{ or } X=(U/H)\ .47 \qquad (3)$$

where H is the corrected hematocrit, .47 represents the ideal hematocrit for males, and X is the total per cent incorporation for the erythrocyte, with correction to the ideal hematocrit.

Results

A comparison was made of the rates of incorporation of Rb^{86}, K^{42}, and Na^{24} by the human erythrocytes of normal subjects over varying time intervals by this technique.* The rates were plotted on semilogarithmic graph paper. The curve for this is shown in the Figure. The graph shows that the rubidium and potassium

* This work was done before corrections were made for cell size; therefore, there is a greater range in the normal data than in the later series.



Comparative rates of incorporation of Rb^{86}, K^{42}, and Na^{24}, by the normal human erythrocyte.

entered the red blood cell in an almost identical fashion over the time intervals studied. The curve for Na^{24} reveals a much lower degree of incorporation of Na^{24} than of K^{42} or of Rb^{86}. The K^{42} and Rb^{86} showed a rapid increase in per cent incorporation by the cells in the first 4 hours, then a slower rate, rising to a plateau in a period of 8 to 12 hours. This is followed by a gradual reentry of the isotope into the plasma, as indicated by a decreased amount of incorporation of the isotope in the red cell.

Only the data obtained after two hours of incubation of the blood with the Rb^{86} are reported at this time. Prolonged incubation produced an increased amount of hemolysis of the cells, thereby making the data obtained invalid.

Blood specimens were studied from seven normal subjects. An additional subject was studied daily for five days to determine whether there was day-by-day variation. The mean value for per cent incorporation of the Rb^{86} for these 12 tests was 57.52%, with a standard deviation of ± 2.85. The range for the subject studied on five consecutive days was 54.2% to 60.6%.

Four critically ill patients were studied. Two had malignant melanoma, with generalized metastases, pleural effusion, and ascites. Both patients had serum potassium levels above normal. The incorporation of the Rb^{86} by the erythrocyte of one patient was significantly low (44.65%) and that of the other at the lower limits of normal (55.5%).

The third patient was a 61-year-old man who had generalized carcinomatosis secondary to a recurrent lesion in the descending colon. This patient was maintained on long-tube suction and parenteral fluids for weeks because of a partial large-bowel obstruction. Shortly before death he had 3.2 mEq/L. of serum potassium with a Rb^{86} incorporation by the red blood cells of 108.1%. The figure in excess of 100% incorporation was due to the correction for hematocrit and mean corpuscular volume in this patient, with a severe iron-deficiency anemia.

The fourth patient had a renal insufficiency following a graft of the abdominal aorta for arteriosclerotic occlusion of the abdominal aorta. He was studied after he began to excrete urine. When his urine excretion was 960 ml. per day, he had 54.9% incorporation of the Rb^{86}. Four days later, at which time his 24-hour urine excretion was 1,600 ml., his Rb^{86} incorporation was 94%. At this time his serum potassium level was 4.1 mEq/L. On the following day, the serum potassium level was 3.7 mEq/L., and the patient had clinical evidence of hypopotassemia. The increased rubidium incorporation was considered an intracellular potassium depletion, which was not reflected by the serum level until the following day. These results are summarized in the Table.

In Vitro Incorporation of Rb^{86} by the Erythrocyte in Four Severely Ill Patients

Patient	Diagnosis	Serum Levels, mEq/L. Na	Serum Levels, mEq/L. K	Rubidium Incorporated, %
1	Malig. melanoma	122	7.2	44.65
2	Malig. melanoma	137	6.0	55.5
3	Carcinomatosis	133	3.2	108.1
4-A	Renal insufficiency	143	4.9	54.9
4-B	Following aortic	133	4.1	94.0
4-C	Graft of abdominal aorta	134	3.7	..

Comment

Twelve studies were done on seven normal subjects for per cent incorporation of Rb^{86} by their erythrocytes by the method described. The mean of the data revealed a small standard deviation. This deviation from the mean is smaller than that reported from the potassium exchange.[1,2,3,5,7,8,23] A small standard deviation gives more significance to the data in abnormal states than in the normal. Another advantage to this study is that it eliminates the prolonged period for necessary equilibration in the potassium exchange evaluations.

The erythrocyte is used in the laboratory method because it is the most readily available cell system for study. This cell system

has been used in a number of metabolic and exchange studies by others.[10-14,19,21,25,27,28] By the method described, the per cent of Rb^{86} incorporated by the erythrocyte of subjects with normal nutrition and electrolytes is compared with that for subjects with abnormalities in their electrolytes. Under the conditions set up in this experimental study, the transport of Rb^{86} or K^{42} across the red cell membrane is influenced by only one factor: the concentrations of potassium on the two sides of the cell membrane. When the intracellular concentration is low, there is a greater percentage of the Rb^{86} incorporated in the erythrocyte. Conversely, when the intracellular potassium level is high, the incorporation of Rb^{86} by the red blood cell is decreased below normal.

Further studies are in progress on patients being depleted of potassium by means of a potassium-free diet.

Summary

A method for evaluation of intracellular potassium by means of the in vitro rate of incorporation of Rb^{86} by the human erythrocyte is presented.

In normal subjects this rate of incorporation after two hours of incubation is $57.52\% \pm 2.85\%$. Patients with a decreased amount of potassium in the intracellular space have a greater rate of incorporation. The rate of incorporation of Rb^{86} is less than normal when excessive intracellular potassium is present.

In one patient, a clinical potassium depletion was anticipated by one day from the data obtained by the method described.

333 E. Huron St. (11).

REFERENCES

1. Aikawa, J. K., Felts, J. H., Jr., and Harrell, G. T.: Isotope Studies of Potassium Metabolism in Diabetes, J. Clin. Invest. 32:15 (Jan.) 1953.

2. Aikawa, J. K.; Felts, J. H., Jr.; Tyor, M. P., and Harrell, G. T.: The Exchangeable Potassium Content in Disease States, J. Clin. Invest. 31:743 (July) 1952.

3. Aikawa, J. K.; Harrell, G. T., and Eisenberg, B.: The Exchangeable Potassium Content of Normal Women, J. Clin. Invest. 31:367 (April) 1952.

4. Ansell, J. S., and Zimmermann, B.: The Use of Stable Rubidium for Measurement of Total Exchangeable Potassium, S. Forum 5:529, 1954.

5. Birkenfeld, L. W.; Leibman, J.; O'Meara, M. P., and Edelman, I. S.: Total Exchangeable Sodium, Total Exchangeable Potassium, and Total Body Water in Edematous Patients with Cirrhosis of the Liver and Congestive Heart Failure, J. Clin. Invest. 37:687 (May) 1958.

6. Burch, G. E.; Threefoot, S. A., and Ray, C. T.: The Rate of Disappearance of Rb^{86} from the Plasma, the Biologic Decay Rate of Rb^{86}, and the Applicability of Rb^{86} as a Tracer of Potassium in Man With and Without Congestive Heart Failure, J. Lab. & Clin. Med. 45:371 (March) 1955.

7. Corsa, L., Jr.; Olney, J. M.; Steenburg, R. W.; Ball, M., and Moore, F. D.: The Measurement of Exchangeable Potassium in Man by Isotope Dilution, J. Clin. Invest. 29:1280 (Oct.) 1950.

8. Edelman, I. S.; Leibman, J.; O'Meara, M. P., and Birkenfeld, L. W.: Interrelations Between Serum Sodium Concentration, Serum Osmolarity and Total Exchangeable Sodium, Total Exchangeable Potassium and Total Body Water, J. Clin. Invest. 37:1236 (Sept.) 1958.

9. Eichelberger, L., and Roma, M.: Water and Electrolyte Distribution in Blood and Tissues of Normal Dogs Following Hypotonic Saline Injections, Am. J. Physiol. 159:57 (Oct.) 1949.

10. Frazier, H. S.; Sicular, A., and Solomon, A. K.: Potassium Uptake by the Dog Erythrocyte, J. Gen. Physiol. 37:631 (May) 1954.

11. Gamble, J. L.: Chemical Anatomy, Physiology and Pathology of Extracellular Fluid, Ed. 6, Cambridge, Mass., Harvard University Press, 1952.

12. Hahn, L. A.; Hevesy, G., and Rebbe, O. H.: Permeability of Corpuscles and Muscle Cells to Potassium Ions, Nature, London 143:1021 (June 17) 1939.

13. Hahn, L. A.; Hevesy, G., and Rebbe, O. H.: Do the Potassium Ions Inside the Muscle Cells and Blood Corpuscles Exchange with Those Present in the Plasma? Biochem. J. 33:1549 (Oct.) 1939.

14. Harris, J. E.: The Influence of the Metabolism of the Human Erythrocytes on Their Potassium Content, J. Biol. Chem. 141:579 (Nov.) 1941.

15. Henegar, G. C.; Foreman, N.; Michaels, G. D., and Kinsell, L. W.: Total Body Potassium as Measured by Radioactive Potassium (K^{42}), S. Forum 5:524, 1954.

16. Kilpatrick, R.; Renschler, H. E.; Munro, D. S., and Wilson, G. M.: A Comparison of the Distribution of K^{42} and Rb^{86} in Rabbit and Man, J. Physiol. 133:194 (July) 1956.

17. Knowles, H. C., Jr.; Alverson, G., and Rubenstein, E.: The Erythrocyte Potassium Concentration in Conditions of Hyponatremia and Hypernatremia, J. Lab. & Clin. Med. 45:463 (March) 1955.

18. Levitt, M. F., and Gaudino, M.: Use of Radioactive Isotopes to Measure Intracellular Cation Concentrations in the Normal Dog, Am. J. Physiol. 159:67 (Oct.) 1949.

19. Love, W. D., and Burch, G. E.: A Comparison of Potassium[42], Rubidium[86] and Cesium[134] as Tracers of Potassium in the Study of Cation Metabolism of Human Erythrocytes in Vitro, J. Lab. & Clin. Med. 41:351 (March) 1953.

20. Love, W. D.; Romney, R. B., and Burch, G. E.: A Comparison of the Distribution of Potassium and Exchangeable Rubidium in the Organs of the Dog, Using Rubidium[86], Circulation Res. 2:112 (March) 1954.

21. Maizels, M.: Cation Control in Human Erythrocytes, J. Physiol. 108:247 (May) 1949.

22. Moore, F. D.: Bodily Changes in Surgical Convalescence: I. The Normal Sequence—Observations and Interpretations, Ann. Surg. 137:289 (March) 1953.

23. O'Meara, M. P.; Birkenfeld, L. W.; Gotch, F. A., and Edelman, I. S.: The Equilibration of Radiosodium (Na^{24}), Radiopotassium (K^{42}), and Deuterium Oxide (D_2O) in Hydropic Human Subjects, J. Clin. Invest. 36:784 (June) 1957.

24. Pinto, H. B.: The Natural History of Rubidium: An Introduction to a Study of Its Role in Physiology, Chem. Abstr. 47:5971 (June) 1953.

25. Raker, J. W.; Taylor, I. M.; Weller, J. M., and Hastings, A. B.: The Rate of Potassium Exchange of the Human Erythrocyte, J. Gen. Physiol. 33:691 (July) 1950.

26. Relman, A. S.: The Physiologic Behavior of Rubidium and Cesium in Relation to That of Potassium, Yale J. Biol. & Med. 29:248 (Dec.) 1956.

27. Sheppard, C. W., and Martin, W. R.: Cation Exchange Between Cells and Plasma of Mammalian Blood: I. Methods and Application to Potassium Exchange in Human Blood, J. Gen. Physiol. 33:703 (July) 1950.

28. Sheppard, C. W.; Martin, W. R., and Beyl, G.: Cation Exchange Between Cells and Plasma of Mammalian Blood: II. Sodium and Potassium Exchange in the Sheep, Dog, Cow and Man, and the Effect of Varying Potassium Concentration, J. Gen. Physiol. 34:411 (March) 1951.

29. Solomon, A. K.: The Permeability of the Human Erythrocyte to Sodium and Potassium, J. Gen. Physiol. 36:57 (Sept.) 1952.

DISCUSSION

DR. JOHN SCHNEEWIND, Chicago: I certainly enjoyed the opportunity of looking over Dr. Henegar's paper. He very kindly gave me a copy of it last night, and I should like to compliment him and his group and Dr. Preston on their excellent work.

At the University of Illinois we get into trouble every so often with patients because of hypopotassemia. We know that the serum potassium is not too reliable. Dr. Henegar's test may be an excellent tool for getting at the root of this matter.

With your permission I should like to show a couple of slides.

[Slide] This is a patient who had had an exploration some years ago. She developed a draining sinus, and in 1939 had a hip fusion for involvement of the spine by an acid-fast organism. She entered Illinois Research Hospital some months ago because of persistence of the fistula, and a colostomy was performed. A fistula between the rectum and the sacrum was found. We got into difficulty here. A colostomy was done to bypass the area, and she had a wound dehiscence eight days after operation. I should like to emphasize one or two things on this slide. This is the point where the wound dehiscence was repaired. She began to get into trouble with some diarrhea and vomiting, and here she was in serious trouble. At this time her sodium was 118 mEq. You will see the potassium was 3.1 mEq. She was given intravenous medication, and gradually the serum potassium rose and other electrolytes began approaching normal figures.

[Slide] These types of patients are notorious for losing a lot of potassium. This patient had a duodenostomy and a choledochostomy. We were not sharp enough to pick this up right away. The patient began to get restless and have abdominal pain. We finally realized that the serum potassium was very low. We began to administer intravenous potassium, and the patient got through it all right when we got her back to normal.

[Slide] This is a fairly typical case with us, a subtotal gastrectomy with large fluid losses from suction and urine. You will note the serum potassium was low, 3.4 and 2.9 mEq. Incidentally, 6 gm. per day is not enough when a patient is in trouble. We do not hesitate to give 12 gm., provided the urine output is reasonable. We have not got into trouble giving larger amounts when the patient needs it. The patient's nonprotein nitrogen, which was high, began to fall. I am sure you are all familiar with the association of a metabolic alkalosis with hypopotassemia, and the hypopotassemia is difficult to treat with this alkalosis.

[Slide] In this last slide we merely point out that it is rather difficult to differentiate between sodium chloride lack and potassium lack, because the clinical symptoms are very similar. Electrocardiography may help.

The point here is that if Dr. Henegar's method proves to be practical it is going to give us an excellent tool by which we may stay out of trouble with some of these patients. One thing he might elaborate on for a moment is whether or not the red cell is consistently uniform in reflecting the potassium content of muscle and liver tissue.

DR. FREDERICK W. PRESTON, Chicago: In studying the electrolyte balance of patients, the cations of most interest are sodium and potassium ions; we measure these in the serum. This is satisfactory for sodium, but possibly we would be better off if we measured the potassium in the cells, since 95% of potassium is intracellular.

Dr. Henegar has taken a laboratory method that has proved to be accurate, and he has changed the time intervals used in the determination from 36 to 2 hours, making it practical for a clinical test that can be applied to patients. It will be interesting to see whether, with more data, this works out to be a useful clinical method.

DR. GEORGE C. HENEGAR, Chicago: I should like to answer Dr. Schneewind's question, which has been asked a number of times in discussing this paper with others—that is, whether or not the red cells give a reflection of the intracellular level, as compared with cells of muscle, liver, brain, and other tissues. A number of studies have been carried out on the tissue spaces of muscle, liver, brain, bone, and intestinal wall. It has been shown that each of these tissues has its individual scheme for taking up potassium and rubidium. However, it is not very practical to take out a block of liver or a block of muscle and make a count on it, as we are able to do with the red cell. The red cell, unfortunately, equilibrates more slowly than liver and muscle, but a little more rapidly than brain and bone.

We chose the red cell for two reasons: One is that it is readily accessible. All that is necessary is to obtain a sample of heparinized venous blood. Second, by using normals and comparing abnormal with normal, we are able to set up normal standards.

I want to point out that the amount of our data is rather small thus far. One reason for this is that much trial and error was necessary in order to establish the correct time intervals, how much blood to use, how much isotope to use, and so on, before we could get reproducible data and have it done in a time interval that was practical. Further studies are in progress, and we are doing studies at the present time on controlled depletion with patients on a formula diet deficient in potassium.

Adjuncts in Hernial Repair

A Consideration of Basic Principles

ROBERT S. SMITH, M.D., Boise, Idaho

For the surgical repair of certain difficult groin and ventral hernias, many adjuncts have been proposed. At the present time, however, autogenous grafts of fascia lata, whole skin, or dermis, and metallic or synthetic meshes seem to be the most popular.

The present report deals with a 10-year experience with hernioplasty. In 108 of 339 patients treated from 1948 to 1958 (Table), adjunctive techniques were considered necessary because of marked tissue deficiency, and in many of these cases the problems of local repair were complicated by obesity and other unfavorable constitutional factors. In 20 cases free strips of fascia lata were used, according to the techniques of Gallie.[1] Tantalum mesh was used in 43 cases; whole skin, in 36; cutis grafts, in 6, and nylon mesh, in 3.

Adjuncts in Hernioplasty

Technique	Inguinal	Ventral	Totals	Recurrences	
Fascia lata	9	11	20	Inguinal	1
				Ventral	2
Tantalum mesh	25	18	43	Inguinal	1
				Ventral	12
Whole skin	19	17	36	Inguinal	1
				Ventral	2
Cutis	3	3	6	Ventral	1
Nylon mesh	0	3	3		0

A significant number of recurrences have been observed in the cases in which adjuncts were used. In general, recurrences have been due to excessive tension in the wound closure, infection, insufficient amounts of tissue transplanted, or fragmentation of metallic mesh.

Read at the 66th Annual Meeting of the Western Surgical Association, Rochester, Minn., Nov. 22, 1958.

Fascia Lata

In the group of cases presented, fascia lata was employed for hernia repair in the form of free-strip implants. Transplantations of large pedicled flaps of fascia lata, or of large free fascial patches, were avoided, as substantially increasing the magnitude of the surgical procedures and leaving defects in the thigh productive of some disability.

Strips of fascia lata are obtained by simple techniques, have great longitudinal tensile strength, and lend themselves to use as autogenous sutures. Fascial sutures have proved very useful in the correction of hernias which are characterized by loss of fascial continuity more than by actual loss of tissue.

The dense avascular structure of fascia lata probably limits the viability of suture implants of this tissue and renders them susceptible to infection.[2] The situation may be somewhat different when free sheets of fascia lata are transplanted to the abdomen. Bricker[3] reports success using sheets of fascia in the repair of large complete musculofascial defects, despite contamination.

Whole-Skin Implants

Skin contains many strong fibrous elements in its deeper layers, and is available in abundance. As a hernioplastic aid, whole skin is usually implanted to support a conventional repair which is considered precarious (Fig. 1), but it may be used to bridge a defect as a complete fascial substitute.

A whole-skin transplant should be fixed in position by nonabsorbable sutures which keep it taut and flat (Fig. 2), and good

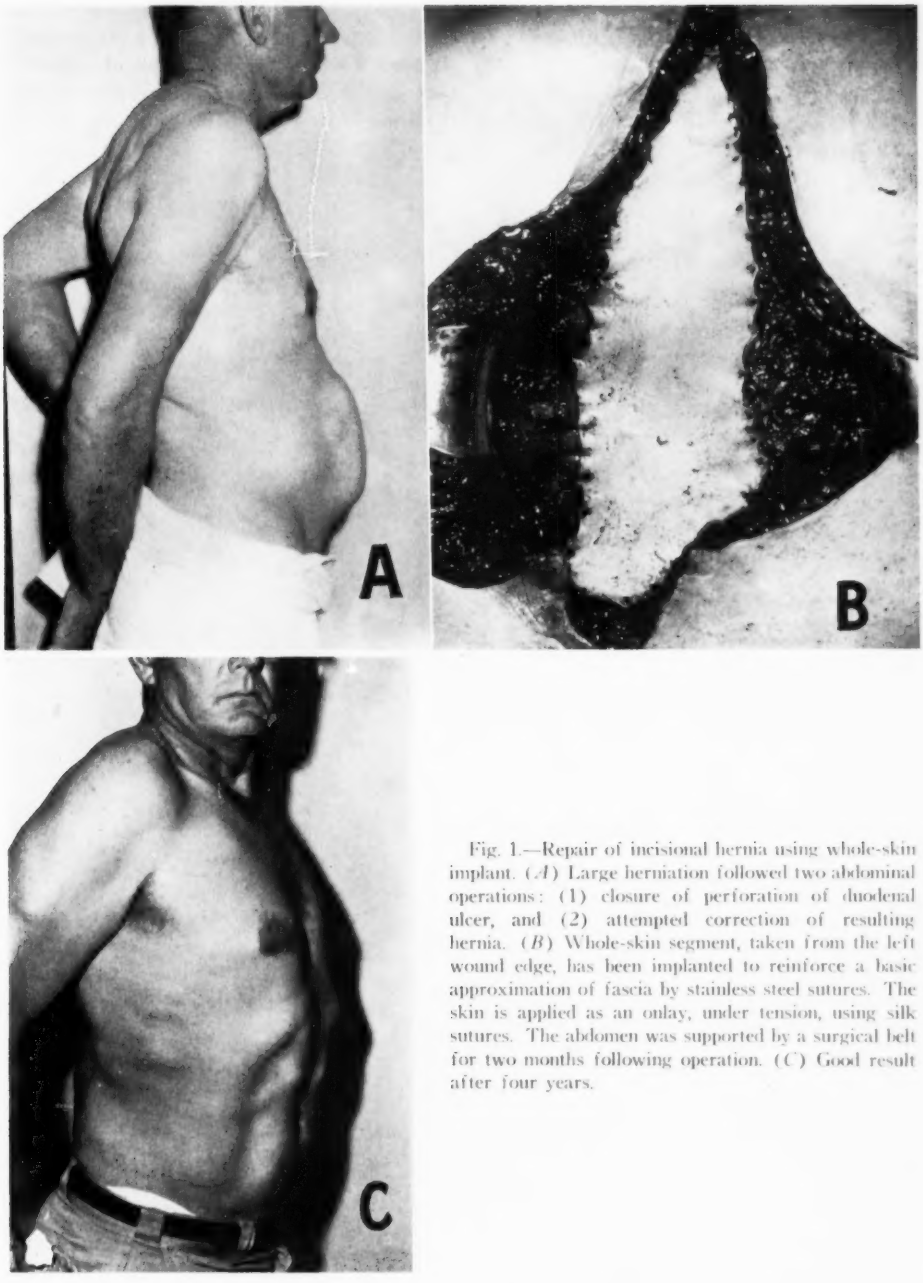


Fig. 1.—Repair of incisional hernia using whole-skin implant. (*A*) Large herniation followed two abdominal operations: (1) closure of perforation of duodenal ulcer, and (2) attempted correction of resulting hernia. (*B*) Whole-skin segment, taken from the left wound edge, has been implanted to reinforce a basic approximation of fascia by stainless steel sutures. The skin is applied as an onlay, under tension, using silk sutures. The abdomen was supported by a surgical belt for two months following operation. (*C*) Good result after four years.

external wound supports should also be provided. Under these conditions, the dermal layer is vascularized, and partial disintegration of the epidermis occurs.[4,5] The epidermal side of a buried piece of whole skin tends to come into equilibrium with the tissues of the new bed, but the attachment on the epidermal side is probably never very firm.[6]

A hazard in the use of whole skin for hernia repair lies in the possibility that the implant may be accidentally displaced before it is solidly healed and fixed in its new bed (Fig. 3). If a skin transplant is torn completely away from its attachments, it usually becomes necrotic; but, if adequate vascular connections are maintained, the loosened skin will tend to grow and roll on itself to form an epidermoid cyst.[7] Necrosis of avulsed skin calls for prompt operative removal of the entire ectopic segment. When graft necrosis occurs, spontaneous

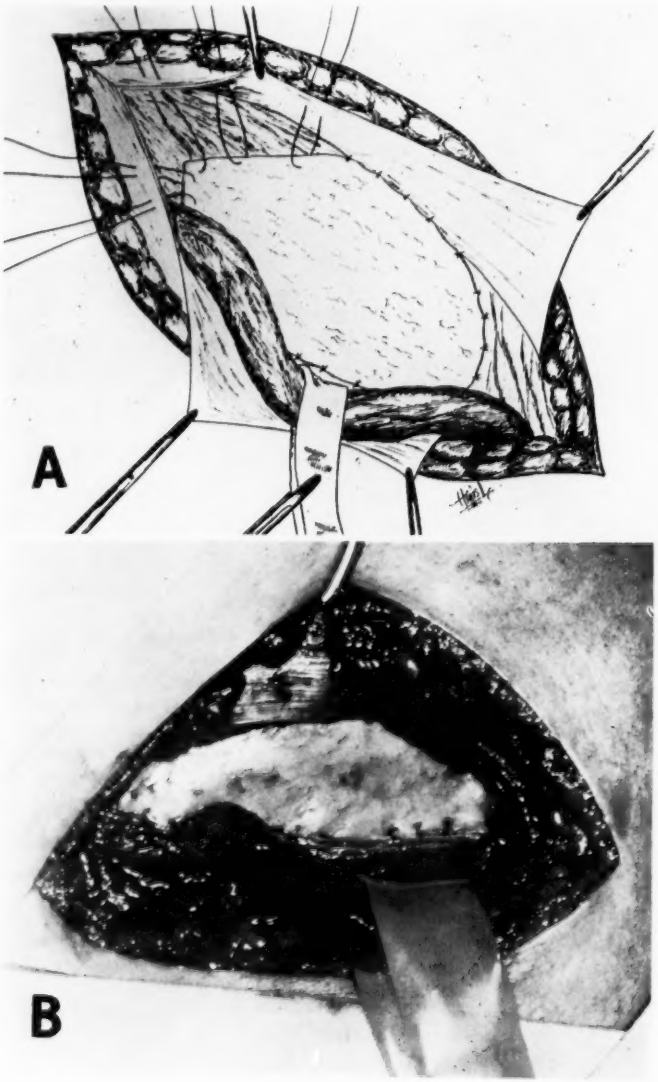


Fig. 2.—Use of skin graft in inguinal hernioplasty. (*A*) Diagram shows a technique of skin implantation in an inguinal repair. The graft, whole skin or cutis, may be sutured below to the inguinal ligament or to Cooper's ligament; at the internal ring, it may be arched over the cord. Above, the anchoring sutures are placed at a distance through the aponeurosis of the external oblique, to prevent rolling up of the graft when the external aponeurotic flaps are brought together over the cord. (*B*) An inguinal repair, as illustrated in *A*.

opening of the wound or inadequate corrective surgery may result in wound infection, and prolonged disability. Epidermoid cyst formation may cause no difficulty in itself, but is frequently associated with hernial recurrence.

It should be emphasized that, as living autogenous tissue, skin implanted in hernial repair is probably as resistant to contamination as other portions of the abdominal wall exposed at laparotomy.[8] In the present series of cases, ordinary skin preparation

Fig. 3.—Avulsion of whole-skin graft implanted in repair of large incisional hernia. (*A*) Chronic open wound of the abdominal wall which resulted after graft avulsion and partial necrosis. Hyperplasia of residual epidermis in the base of the wound interfered with several attempts at secondary wound closure by ordinary techniques. (*B*) Section from base of wound after four months shows typical skin. (*C*) Healing was accomplished after seven months by accepting growth of squamous epithelium in the base of the wound and applying additional skin in the form of split grafts to complete the coverage. Abdomen strongly supported after three years.

was used before surgery, and antibiotics were administered before and after operation on a prophylactic basis. No wound infections were observed in any case in which healing was uncomplicated by graft avulsion. There was no evidence of infection in six cases in which skin implants were made in the presence of bowel contamination.

Cutis Grafts

As employed in hernial repair, a cutis graft may be considered to be a refined whole-skin graft, readily prepared by the dermatome removal of the upper layers of the skin.[9] In the typical cutis implant, lightly split by the dermatome, a certain number of epidermal appendages are uniformly retained in the dermis, but cause no difficulty. The dermis is the important stratum of all skin grafts used in hernioplasty. Under tension in the body, this layer actually seems to develop an increased fibrous character, suggestive of a metaplasia.[10-12]

In the preparation of a cutis graft, the removal of the stratified squamous epithelium opens up another side of the skin implant for vascularization and fibroblastic penetration. As compared with whole-skin transplants, cutis grafts may be expected to heal more rapidly and more solidly in a buried position, and should be less subject to avulsion.

Tantalum Mesh

The chief virtue of tantalum as a hernioplastic adjunct lies in its quality of inertness. Even in the presence of infection, wounds have healed solidly over mesh implants of this metal.[13-15] The great disadvantage of tantalum mesh lies in its well-known tendency to work hardening and fragmentation in the abdominal wall.[16,17] Break-up of the mesh usually occurs in the first year following implantation, as the scar tissue associated with it begins to soften and thin out.

In the present series, ventral-hernia recurrence has frequently followed tantalum-mesh fragmentation. Results have been better in a group of inguinal repairs supported by mesh implants. Tantalum-mesh fragmentation occurs in the groin, but in this area the metal is not as readily displaced as in the upper abdomen. In inguinal repairs, involvement of the spermatic cord by late dislocation of mesh fragments is a possibility.

Nylon Mesh

A limited experience has been had with nylon mesh [18] as an adjunct in the primary repair of large complete musculofascial defects resulting from the resection of abdominal-wall tumors. The immediate results have been good, in that healing has occurred rapidly and the abdominal repairs have appeared strongly supported. The long-term results in these cases remain to be seen.

A word of caution would seem in order, since experimental work [19-21] suggests that, in the event of infection, many synthetics will tend to be rejected by the tissues as foreign bodies. With longer experience, some synthetics may also prove to be fragmentable.

Summary

Each technical adjunct of the present report appears to have its own peculiar surgical virtues and defects, and each probably has a field of usefulness.

In selecting a hernioplastic aid, the surgeon should evaluate each possible adjunct from the standpoints of basic tensile strength, tolerance by the tissues, resistance to infection, and susceptibility to work hardening.

It is important for the surgeon to recognize inherent potential hazards in any supplementary technique, in order that complications may be avoided.

312 W. Idaho St.

REFERENCES

1. Gallie, W. E., and LeMesurier, A. B.: The Use of Free Transplants of Fascia as Living Sutures in the Treatment of Hernia, Arch. Surg. 9:516, 1924.

2. Burdick, C. G.; Gillespie, D. H. M., and Higinbotham, N. L.: Fascial Suture Operations for Hernia: Summary and End-Results of 1,485 Operations, Ann. Surg. 106:333, 1937.

3. Bricker, E. M.: Personal communication to authors.

4. Mair, G. B.: The Use of Whole Skin Grafts as a Substitute for Fascial Sutures in the Treatment of Hernias, Am. J. Surg. 69:352, 1945.

5. Smith, R. S.: Versatility of the Free Skin Transplant, West. J. Surg. 63:107, 1955.

6. Gray, D. B.; Mansberger, A. R., Jr., and Yeager, G. H.: Fate of Buried Full-Thickness Skin, Ann. Surg. 134:205, 1951.

7. Strahan, A. W. B.: Hernial Repair by Whole-Skin Graft, with Report on 413 Cases, Brit. J. Surg. 38:276, 1951.

8. Zavaleta, D. E., and Uriburu, J. V., Jr.: Whole Thickness Skin Grafts in the Treatment of Hernias: Analysis of 211 Cases, Surg. Gynec. & Obst. 91:157, 1950.

9. Harkins, H. N.: Cutis Grafts: Clinical and Experimental Studies on Their Use as a Reinforcing Patch in the Repair of Larger Ventral and Incisional Herniae, Ann. Surg. 122:996, 1945.

10. Uihlein, A., Jr.: Use of Cutis Grafts in Plastic Operations, Arch. Surg. 38:118, 1939.

11. Cannaday, J. E.: Some of the Uses of Cutis Grafts in Surgery, Am. J. Surg. 59:409, 1943.

12. West, W. T., and Hicks, E. S.: Skin as a Supporting Graft in Repair of Herniae, Canad. M. A. J. 58:178, 1948.

13. Koontz, A. R.: Tantalum Mesh in Hernia Repair, J. Internat. Coll. Surgeons 15:748, 1951.

14. Koontz, A. R.: Tantalum Mesh in the Repair of Large Ventral Hernias, Surg. Gynec. & Obst. 93:112, 1951.

15. Crile, G., Jr., and King, D. C.: Successful Use of Tantalum Mesh to Repair an Abdominal Wall Defect in the Presence of Massive Fecal Contamination, Surgery 29:914, 1951.

16. Flynn, W. J.; Brant, A. E., and Nelson, G. G.: A 4½-Year Analysis of Tantalum Gauze Used in the Repair of Ventral Hernia, Ann. Surg. 134:1027, 1951.

17. Smith, R. S.: The Uses of Tantalum Mesh in Hernia Repair, West. J. Surg. 62:1, 1954.

18. Joseph, M.: Conservation of Morbidity in Hernia Repair: New Agent for Recurrent Hernia, West. J. Surg. 62:582, 1954.

19. Koontz, A. R., and Kimberly, R. C.: An Evaluation of the Usefulness of Fortisan Fabric in Hernia Repair, Ann. Surg. 139:644, 1954.

20. Sanford, J. P.; Riley, P. A., Jr., and Sauvage, L. R.: Evaluation of Orlon Fabric in the Repair of Defects in the Abdominal Wall, Surgery 39:236, 1956.

21. Lemons, J., and Laufman, H.: Limitations of Synthetic Fabrics as Peritoneal Substitutes, A. M. A. Arch. Surg. 76:593, 1958.

DISCUSSION

DR. CHESTER B. MCVAY, Yankton, S. D.: I wish to compliment Dr. Smith on this excellent and very timely paper on one of our major problems in the treatment of hernias of the abdominal wall. I am going to confine my remarks primarily to the very large incisional hernia, except in passing to say that we have used a prosthesis in less than 1% of groin hernias.

I think it is well to put in a word of caution, and Dr. Smith has alluded to this: Let us not use a prosthetic device unless it is absolutely necessary. There are complications with all of them. The average incisional hernia can be very nicely repaired with available musculoaponeurotic material if the surgeon will use a little ingenuity and will take the time to evaluate the available material.

It is in the very large incisional hernia that I am sure most of the difficulty lies—hernia in which the margins cannot be approximated, even under deep surgical anesthesia. My experience has been almost entirely with stainless steel wire mesh, but I don't think this has any advantage over tantalum. In 1949 we made the switch simply because it is easier to work with, and stainless steel wire is easier to handle than the more brittle tantalum.

[Slide] This slide shows an enormous incisional hernia through a combined incision. This defect extends from the costal margin to the pubic crest.

[Slide] I am not going into any detail about how this is repaired, as that is not the province of a discusser of a paper. I want to point out the size of this defect and something I think is not well understood. In the disintegration of a wound and the formation of an incisional hernia there certainly is some loss of tissue, but it is very minimal. I would call your attention to the dotted line and the broad area showing the shift of the musculoaponeurotic junction of the transversus muscle. I simply show this to emphasize that in large hernias we are dealing with muscle contraction, and at least under surgical anesthesia at the time of operation it is impossible to overcome that retraction.

[Slide] As I said, our experience has been with stainless steel mesh, and we have followed our cases rather closely. As mentioned, the break-up of the mesh begins in about one year.

This drawing was made from an x-ray in 1954; the hernia had been repaired in 1952. You can see the beginning fragmentation. The circles represent steel wire sutures; notice how they have come loose. I do not have a current drawing, but a year ago this man was checked, and the wire was completely fragmented, seven years after the repair of his hernia.

[Slide] This patient, however, has an excellent result, some eight years after the repair of his large defect. I should point out that this man is slender, and he is one of nature's noblemen. He has ducked work for the past 50 years, and did not change his habits after having his hernia repaired.

This patient, however, extremely obese and a farmer, does heavy work. If none of you has had the experience of repairing a recurrent incisional hernia through wire mesh, you have really missed something.

I show only one defect here. Actually, this man has had three recurrences, one in the center, one above and one below the sheet of wire mesh. The repair is a time-consuming procedure. Once the mesh is in place and it becomes organized, it is almost impossible to remove without removing a section of the abdominal wall.

So with mesh I think a great deal depends upon the habitus and habits of the patient. A cooperative patient should have a good result. An uncooperative patient will have an excellent chance of recurrent trouble. As regards other adjuncts in the repair of these hernias, it would seem to me that the dermis graft perhaps offers the most, especially if it can be proved that the elastic fibers live in the deep layers of the dermis. All we are left with in the repair of these large hernias with any other prosthetic device, other than a pedicle flap, is a dense area of scar, and the scar eventually stretches.

Dr. Tom D. Throckmorton, Des Moines, Iowa: I arise to say a few good words about tantalum gauze. I first employed tantalum gauze in 1944 and reported on 17 tantalum gauze herniorrhaphies in 1948. In this particular group of cases reported, there have, to date, been no recurrences. I do not mean to say that in any case in which I have used tantalum gauze there has been no recurrence, because there have been recurrences. I do not know of any adjunct or any other operation without an adjunct for which I will guarantee no recurrence.

First, tantalum gauze and stainless steel gauze are not the same thing. In the first place, stainless steel will work-harden twice as quickly as tantalum. The other point is that stainless steel is a polished type of implant; tantalum gauze is made from an easily oxidized metal, and tantalum is invariably coated with tantalum oxide. Pure tantalum does not contact the tissue; as far as the tissue is concerned, the implant consists of a mesh of tantalum oxide. Tantalum oxide is quite irritating and will lay down a very heavy scar. I think we should accept the fact that when implanting a sheet of tantalum gauze we are merely implanting a scaffold over which scar tissue may grow. The tantalum gauze does not contain the hernia for any period of time, but the envelope or sheath of scar tissue is the actual substance of the repair.

Second, I have found that recurrence with tantalum gauze almost invariably occurs when the gauze is anchored over a considerable distance between an area which moves and an area which does not move. A typical instance would be the implantation of a large segment of tantalum gauze in the abdominal wall between the costochondral margin and the anterior superior iliac spine.

Third, I thought that at one time I had an answer to this problem and have used Ivalon sponge in compressed sheets. This works beautifully. I have reported on about 60 cases in which this has been used, but of late have stopped its use, at least temporarily, because of the ubiquitous Staphylococcus aureus. If an Ivalon implant is involved by bacterial inflammation, it leads to the ultimate removal of the Ivalon implant, whereas, as Dr. Smith brought out, tantalum gauze may lie for a time in a pool of pus and none the less heal with a satisfactory result.

Fourth, the repair of certain large hernias associated with tissue deficiency is essentially a process of good tailoring. If the bolt of goods presented by the patient is adequate for the job, a good result can be anticipated. However, if the tissue material supplied by the patient to the surgeon is utterly inadequate for a satisfactory repair, then it is only good surgery to consider a tissue substitute.

Dr. Herbert M. Nichols, Portland, Ore.: The great variety of procedures which has been described for the repair of large hernias in the abdominal wall points up the fact that nothing is entirely satisfactory. The central part of the abdomen acts as a tendon, with muscles pulling on both ends of it. In the hand a tendon repair can be made early in drawing the tendon ends together. In late cases a tendon graft is usually necessary because the muscle has retracted and remained so. A similar situation occurs in large, old hernias.

The use of prosthetic devices is attractive because of simplicity and ready availability. Unfortunately, in the long run, the body only tolerates these devices but does not turn them into living tissue. In old people it is all right to use a hip prosthesis, but in younger persons the metal will loosen up from the femur and changes occur in the hip joint. I am sure that, in the long run, metallic mesh will be unsatisfactory in a large proportion of cases if it is being used actually to bridge a defect. As far as nylon is concerned, the experimental work which I published in 1940 showed that nylon is more irritating than silk, and I have now discontinued using it, especially since it was found that some people were actually allergic to it.

Perhaps the use of the metaplasia factor of primitive tissues may offer a valuable aid in the repair of hernias where true defects exist. We know that sometimes the peritenon which is put in around a tendon graft will proliferate out of all proportion to its original thickness and may thicken enough to cause an actual contracture—some surgeons have given up using it for this reason. This is a true example of metaplasia. I suggest that a similar process occurs when dermis is used to repair a defect in the abdominal wall.

DR. CHESTER C. GUY, Chicago: This interesting paper by Dr. Smith opens up avenues which we might pursue for many hours in our discussion. I am going to limit my brief comments to the problem of inguinal hernia.

[Slide] We must conclude that recurrent hernia is a surgical affair; and if we are going to solve this problem, it would seem to be on the basis of a sizable number of cases repaired by various methods and followed over a considerable period of time. In 1949 we quit using fascial transplants and skin grafts, as our experiences with them were unsatisfactory. We started using tantalum mesh in those hernias that were large or recurrent or where the fascia seemed inadequate to ensure a satisfactory result, particularly the direct hernias in older men.

During the eight years from 1949 to 1956, inclusive, on one service at the Illinois Central Hospital, Chicago, we operated on 1,865 inguinal hernias. We repaired 1,297, or approximately two-thirds of them, without using tantalum mesh. We used the mesh in 568, or about one-third. In only 1 of these 568 hernias was it necessary to remove the mesh at a later date.

[Slide] We are in the process of preparing a paper of our results, and this is a preliminary report. Our follow-up is excellent, but it is not perfect; and we have not had the opportunity to reexamine all of these patients. It is, of course, only by such a personal reexamination that one knows the actual percentage of recurrences. So we refer to our known recurrences. In this series of 1,865 inguinal hernias which we repaired ourselves, and which have been followed for 2 to 10 years, from 1949 up to the time these figures were compiled—about 10 days ago—there are 71 known recurrences. In the simpler hernias which we repaired without mesh, when we thought we did not need it and probably would get a good result without it, we know of 61 recurrences, or 4.7%. In the more difficult hernias which we repaired with mesh, we know of 10 recurrences, or 1.76%. Our own experiences mean more to us than those of anybody else. In our experience, we are completely satisfied with the use of tantalum mesh in the repair of the more difficult inguinal hernias. With its use we can reduce our recurrence rate over a 10-year period by at least two-thirds.

DR. CARL B. DAVIS JR., Chicago: Some years ago we presented before this Association our experiences in a series of cases in which the anterior rectus sheath was utilized in the repair of inguinal hernia. We suggested at that time that a properly and carefully tailored flap of the anterior rectus sheath can be used to strengthen Hesselbach's triangle and the so-called lower critical angle of the inguinal canal. We have continued to employ this technique, with many satisfactory results.

It must be emphasized, however, that the procedure is not recommended in all cases of inguinal hernia repair, but has been reserved for patients with large recurrent inguinal hernias, with patients with a weak or conjoined tendon or absent conjoined tendon, and in some direct hernias with inadequate transversalis fascia. If one does not choose to turn a rectus sheath flap, the relaxing incision in the anterior rectus sheath, as advocated by Dr. McVay, may be used to advantage. Although some surgeons may regard with skepticism the use of such an autogenous, pedicled graft of the anterior rectus sheath in the repair of inguinal hernia, we cannot help feeling that the use of foreign materials or free-tissue grafts is not without complications.

[Slide] Some weeks ago a 55-year-old patient was referred to Dr. Puestow, of our hospital, for treatment of a complication involving the use of tantalum mesh. This patient, operated upon elsewhere, had been subjected first to a bilateral inguinal herniorrhaphy in 1955, and, because of bilateral recurrence two years later, tantalum mesh was employed in the second repair. An

additional supporting patch of tantalum was inserted on the right side earlier this year by the outside physician. Severe pain is now experienced in the region of both these subcutaneous foreign bodies.

[Slide] This slide obviously demonstrates the mesh in the soft tissues. These fragments are readily palpable and cause the patient severe pain when one lightly palpates the inguinal areas. He is anxious to have these foreign bodies removed.

[Slide] This drawing illustrates a semilunar incision used in the preparation of the flap of the anterior rectus sheath.

[Slide] This shows the rectus-sheath flap sutured in place to strengthen Hesselbach's triangle.

[Slide] A 63-year-old patient with a 20-year history of a large scrotal hernia was operated on by us nine years ago. A large sliding inguinal hernia was reduced and repaired, using a graft prepared from the anterior rectus sheath. To date there has been no evidence of recurrence.

[Slide] A middle-aged woman with a dependent swelling over the pubic area consistent with the seventh recurrence of a right inguinal hernia was referred to us for the first time for a subtotal thyroidectomy. After an uncomplicated procedure on the thyroid gland, she consented to reoperation on this hernia. At the seventh operation performed in a major clinic in this country, the record indicated that fascia lata had been used as a free graft. [Slide] At our operation, a rectus sheath flap was turned in this patient, and now, five years since operation, there is no evidence of recurrence.

In summary, these cases and others have suggested that this technique can be used to advantage in the management of properly selected patients requiring inguinal hernia repair, and that a strong fascia-to-fascia reinforcement of the floor of the inguinal canal can be accomplished if a properly fashioned flap of the anterior rectus sheath is employed.

DR. CHARLES G. JOHNSTON, Detroit: Tom Throckmorton prefaced his remarks by saying he wanted to say a word for tantalum. Before this discussion closes, I think someone ought to say a word for surgery in the cure of hernias. [Laughter]

So far I have heard very little—except in the last discussion—about using what the patient has. I think we might start out by saying that for over 20 years at the Detroit Receiving Hospital, and at the Dearborn Veterans Hospital for 10 years, we have not used any prosthesis, any free grafts, anything in repair of hernias except surgery.

I think this is a plastic procedure that requires ingenuity. I have yet to see one in which there is not tissue enough in the region to give all the support one needs, and I have insisted that surgery be used—good, clean, delicate surgery, the same as that we are supposed to use anywhere else in the repair of hernia. I said we have not used prostheses in our hospital. Some years ago one of my associates maintained that I was too hard and fast about this, and too dogmatic, and that other people were using tantalum mesh and that we should, too; so I said: "We will assign you the task of using it. It is expensive. How about six pieces? I will buy you six pieces, and you put them in—but put them in where they are indicated, please. In other words, use them in hernias that you think are going to be hard to close without some prosthesis. Don't pick little ones. I insist on only one thing—that when the patients come back, I see them; that if they have a recurrence, I operate on them and you stand by, and let me repair them without anything but their own tissue." Five of the six came back with recurrences. You might say he did not know enough about doing the procedure—but he was a good, competent surgeon. We took out the mesh and repaired the hernia in each of the five cases with tissue in the area. These were ventral hernias.

Inguinal hernias are another problem. Repair of this hernia is a beautiful anatomical operation. I see no need to put in a lot of foreign material; there is usually plenty of tissue available.

Further, in a teaching institution I see no reason for permitting the use of a prosthesis when not necessary, for a young man ought to learn how to do surgery, and do it well; then if he is stuck and everything else fails, he can try various types of prostheses.

After hearing the discussion this morning, I think we lean upon foreign materials too much. We depend on a lot of prostheses that give us a great deal of trouble, and I believe the majority of hernias can be handled without them, even the large ones. We have some of moderate size at the Receiving Hospital. I do not remember refusing to operate on any of them because of their size. Even in big ventral hernias we do not use foreign materials of any sort. We build up layers, and what not, to help us. With care and patience, and with good surgical technique, the majority of these cases can be repaired without any difficulty and without masses of foreign materials.

DR. GORDON K. SMITH, Los Angeles: I don't wish to prolong this discussion any longer. I am going to throw my carefully prepared extemporaneous speech away. When Dr. Smith asked me to discuss this paper, I told him I had had very little experience with prostheses. I should like to confine my few remarks to the inguinal hernia.

In 1954 we made a study at the Hospital of the Good Samaritan, in Los Angeles, and were amazed to find that 61% of the patients who were admitted for repair of recurrent inguinal hernia had indirect recurrences, and that of these indirect recurrences, almost 9% were sliding hernias. Therefore, at that time we began using the LaRoque combined abdominal-inguinal incision for the repair of sliding hernias and also for the repair of the large, indirect defect.

Additionally, in men past 60 who have defects of the internal ring, we have no hesitation in dividing and resecting the spermatic cord, taking care to leave the testicle in place. We have not had to remove any testes after this procedure.

I think Dr. Davis' remarks regarding the rectus flap were fine, except that I believe that the rectus flap should be sutured to Cooper's, not to Poupart's, ligament.

DR. JOHN GRINDLAY, Rochester, Minn.: One danger with nylon, I am told by polymer research chemists, is that nylon is no longer what it was when it was first used. The original nylon polymer is unobtainable now. Not only is nylon now a polymer different from the original, but there are several kinds of nylon polymers, each having its virtues for nonmedical uses, such as for fabrics or gaskets. Polymer chemists are quite concerned that these nylons will be depolymerized in time in tissue at body temperature, and it is quite possible that they will become carcinogenic or sarcogenic.

The other caution that might be mentioned is that metallic implants have as a common fault the fact that they cause intense pain when the victim is in the field of radar waves, or of any microwaves. That may not be so important right now, but the Navy, for example, has encountered trouble in its personnel. As I understand it, metallic implants act as antennae for micro or radar waves. The energy received by the waves is dissipated among adjacent tissues in the form of heat—and the heat evokes discomfort, even intense pain. Accordingly, in these days of ever-increasing exposure to electronic apparatus, surgeons should be wary about placement of metallic prosthesis in patients, especially younger patients.

DR. WILLIAM H. MORETZ, Augusta, Ga.: I would like to compliment Dr. Smith on his very interesting paper, and also heartily endorse Dr. Johnston's remarks. As Dr. Johnston had a word to say for surgery, I would like to say a word for Teflon. Certainly, it seems to us that the ideal substitute for body tissues, when occasionally needed, is the new plastic Teflon. It has been proved by laboratory experiments that its tensile strength remains almost unchanged for at least two or three years, a property in which it is unlike most other plastics, certainly nylon.

Our experience with the metal meshes has been almost entirely in the line of taking them out. We have not put them in, but we have removed them, and it is a horrible mess when the hernia has recurred and reoperation is indicated.

We have used Teflon in only a few cases because, as Dr. Johnston has indicated, we feel that very seldom is the use of a prosthesis necessary. We have used Teflon in a few ventral hernias, as well as in the replacement of part of the chest wall following the Urban type of superradical mastectomy, and also in the replacement of the pelvic floor following a pelvic exenteration. We have not been at all disappointed in its use. It seems to us to be rather ideal when a substitute is needed, as it relatively seldom is. One particular feature should be called to your attention if Teflon is to be used. It is so inert and so unreactive in tissues that it is not normally invaded by fibrous tissue. Therefore, if it is to be used for such purposes, it probably should not be a close-weave material, but of a very loose weave, such as that which has recently been made to the specifications of Dr. Harold Harrison, of Atlanta. This particular type of weave, although the material itself is not invaded, does allow scar tissue to grow through the holes between the fibers, therefore helping to anchor it in place. If, on a few occasions, substitutes are needed I would recommend the use of Teflon, since it probably would have the best chance of succeeding.

DR. ROBERT S. SMITH, Boise, Idaho: I wish to thank the various discussers. This subject apparently is a live one. In view of the various divergent opinions expressed this morning, I believe that we have not heard the last word on hernial adjuncts.

Relationship of Peptic Esophagitis to Spontaneous Rupture of Esophagus

JOHN M. DORSEY, M.D.; ROBERT P. HOHF, M.D., and THOMAS E. LYNN, M.D., Evanston, Ill.

Spontaneous rupture of the esophagus is a serious, and often fatal, condition unless there is prompt surgical intervention. The onset of symptoms is usually abrupt and almost always related to an episode of vomiting. The most frequent site of rupture is at the inferior end of the esophagus and on the left. Initially, severe lower substernal or upper abdominal pain with associated shock may be preponderant. Diagnostic confusion with more frequently encountered conditions of the thorax or upper abdomen is common. Subsequently the features of mediastinitis, with usually an associated hydropneumothorax, predominate. The fulminating course and high mortality in untreated patients make early recognition and operative intervention urgent.

A review of the Evanston Hospital records prior to 1946 failed to disclose a reported case of spontaneous rupture of the esophagus. Since that time nine such instances have been encountered. These cases form the basis of this report.

Background

Rupture of the esophagus was first described by Boerhaave[3] in 1724. The onset of symptoms developed after induced vomiting, and the patient died approximately 18 hours later. In 1944 Graham[11] described two cases of spontaneous esophageal rupture with survival after surgical drainage of an associated hydropneumothorax. A review of the literature, in 1946, by Eliason and Welty[8] failed to disclose any other survivors. In 1947 Barrett[2] reported the survival of a patient who had an operative closure of the perforation approximately 10 hours after the onset of symptoms. Shortly thereafter, Olsen and Clagett[15] reported another successful operative result. More widespread awareness of the condition has led to an increasing number of reported cases in recent years. If not treated, the condition usually proves fatal. A few patients have recovered without repair of the rupture. They developed a spontaneous pleural cutaneous fistula or had an operative drainage of the involved pleural cavity. There is considerable morbidity associated with such a situation. Early operative closure of the rupture usually results in success, with a minimal morbidity rate. The course parallels that of properly treated perforations elsewhere in the gastrointestinal tract. The morbidity and mortality progressively increase with delay in treatment.

Etiology

It is agreed generally that rupture of the esophageal wall usually results from an abrupt onset of excessive pressure within the esophagus. It is most frequently associated with vomiting. Frequently, there is a preceding excess of eating or drinking. Cases have been reported, however, after the lifting of a heavy object, while straining during childbirth or in defecation, during an epileptic seizure, or after a direct blow to the abdomen.

Read at the 66th Annual Meeting of the Western Surgical Association, Rochester, Minn., Nov. 22, 1958.

From the Department of Surgery, Northwestern Medical School, Chicago, and the Evanston Hospital.

Professor of Surgery (Dr. Dorsey); Associate in Surgery (Dr. Hohf), Northwestern Medical School. Formerly Chief Surgical Resident, Evanston Hospital; now at Gosin-Lynn Clinic, Green Bay Wis. (Dr. Lynn).

Various authors, including Kinsella et al.,[13] Samson,[17] and Mackler,[14] have suggested, on the basis of animal experiments and bursting pressures in fresh human cadavers, that the rupture may be due to a failure of the esophagus to relax in the normal manner. An extrinsic obstruction (e. g., bolus of food) has also occasionally been implicated. Weiss and Mallory[18] postulated that fatigue of the vomiting center, after repeated emesis, could alter the vomiting reflex, leading to uncoordination and lack of relaxation of the esophagus. Derbes and Mitchell[6] demonstrated experimentally the hydrodynamic forces involved and explained the almost uniform occurrence of a longitudinal tear of the esophagus. Factors implicated for the almost consistent rupture in the lower left esophageal wall have included angulation of the esophagus in this area, thinning of the esophageal muscles, entrance of vessels and nerves, and less external esophageal support.

While perforation of the esophagus can be produced by mechanical factors alone, local esophagitis and ulceration will weaken the esophagus and predispose it to rupture. Dorsey and Kyser[9] have emphasized the importance of peptic esophagitis as a factor predisposing to esophageal rupture. Ferguson and his associates[10] demonstrated experimentally that the esophagus is much more resistant to pressure rupture than is the fundic end of the stomach or the cecum. However, ligation of the pylorus, adequately maintained with parenteral fluids, resulted in perforation of the esophagus within four days in four of eight dogs subjected to this experiment. Esophagitis was observed in all eight animals, whereas no dog showed evidence of gastric pathology. The same workers found that when acid peptic juice collected from an isolated pouch in the dog was dripped into the esophagus at a maintained intraluminal pressure of 20 cm. of fluid, severe esophagitis with perforation always followed. Derrick and associates[7] found that the bursting strength of the intact human esophagus is reduced three times if the mucosa is removed. They emphasized that even so minor a mechanical stress as vomiting might rupture an esophagus that is the site of peptic esophagitis.

Harrington[12] stated that the reason that most esophageal ruptures occurred in the inferior left posterolateral aspect of the esophagus was that they were actually perforated gastric ulcers. This area could represent a true portion of the stomach or be the site of ectopic gastric glands.

Cushing[5] emphasized the relationship of the interbrain to peptic ulcer. Richter and co-workers,[16] among others, have substantiated the stimulating effect of cerebral lesions on gastric secretion. The increased incidence of rupture of the esophagus among neurological and neurosurgical patients would support this thesis. The relatively higher frequency of esophageal rupture in patients with thermal burns suggests that a so-called Curling's ulcer may appear in the esophagus, similar to that observed in the duodenum. It is probable that peptic esophagitis is initiated during the alarm reaction in these and other stress situations.

Clinical Aspects

Over three-quarters of the reported patients have been male, and the majority have been more than 40 years old. However, a recent review by Derbes and Mitchell[6] disclosed that 10% of cases have occurred under the age of 20.

The onset is usually sudden and may be so precipitous that some form of poisoning is considered. Characteristically, while retching or vomiting, the patient is abruptly seized with severe pain in the epigastrium or lower substernal area. Not infrequently the vomitus will be blood-tinged or, on rare occasions, frankly bloody. There may be the sensation of something "giving away."

Rarely the pain may be minimal, but is generally described as "knife-like" with increasing severity, and is commonly rather refractory to analgesics. Radiation to the back or interscapular region is frequent. The pain is usually aggravated by breathing, and the respirations tend to be rapid,

shallow, and grunting in character. Movement generally increases the pain and may make examination difficult.

An attempt to swallow fluid or food usually accentuates the discomfort, and may initiate an episode of coughing if there is a pleural communication. Extreme thirst is a common symptom.

On physical examination the patient appears critically ill. Marked restlessness and apprehension are seldom absent. Some degree of shock is frequently present early, and this becomes more profound with the passage of time. Dyspnea is almost always present, and associated cyanosis is common.

The physical findings in the chest are frequently normal if the patient is examined soon after onset of symptoms. Subsequently, abnormal findings are usually present, but may be rather variable, depending on the duration of symptoms and whether a pleural communication is present. Evidence of pleural effusion, pneumothorax, hydropneumothorax, or pneumonitis is often found on physical examination at some time during the course of the illness. Compression of the mediastinum may produce findings compatible with the superior mediastinum syndrome. As the process progresses, subcutaneous emphysema may appear in the neck and spread into adjacent areas. It may be completely absent, but when present is an extremely important diagnostic clue. The continued absence of mediastinal or subcutaneous emphysema suggests a direct perforation into a free pleural space. Initially, tenderness and guarding of the abdominal wall, especially in the epigastrium or upper abdomen, may be the predominant findings. Upper abdominal rigidity is marked on occasion. A diagnosis of a perforated intra-abdominal viscus has frequently been considered.

The differential diagnosis commonly includes coronary occlusion, dissecting aneurysm of the aorta, pulmonary embolism, spontaneous pneumothorax, incarceration of a diaphragmatic hernia, perforated peptic ulcer, acute pancreatitis, and a mesenteric vascular occlusion.

Roentgenography of the thorax is the most valuable laboratory test. Some abnormality will be noted in 90% of cases. Bunch [4] emphasized the added value of also obtaining a lateral roentgenogram of the thorax. The commonest findings are hydrothorax, hydropneumothorax, and emphysema of the mediastinum and neck. Even when the process is confined to the mediastinum, a small pleural effusion is frequently evident, and the roentgenographic picture is primarily that of mediastinitis with a markedly widened mediastinal shadow (Fig. 1*A*). The roentgenographic features often precede definitive physical signs by hours. Not infrequently the roentgenographic findings will initiate consideration of a previously unsuspected esophageal tear. The presence of a massive, rapidly increasing hydropneumothorax strongly suggests a rupture of the esophagus (Fig. 1*B*). The hydrothorax may be further complicated by a tension pneumothorax, with considerable shift of the mediastinum to the opposite side (Fig. 1*C*). The hydropneumothorax may be bilateral. Pneumothorax with minimal or slow accumulation of fluid is more compatible with spontaneous pneumothorax. Mediastinal emphysema can occur after rupture of a gastric or duodenal ulcer, but almost always there is an associated collection of subdiaphragmatic air. Roentgenographic demonstration of an esophageal fistula with contrast medium confirms an esophageal tear. Aspiration of gastroduodenal contents from the pleural cavity also establishes the diagnosis.

Treatment

The treatment of spontaneous esophageal rupture consists essentially of a prompt thoracotomy and surgical repair of the esophageal tear. It is also essential to institute adequate drainage of the mediastinal and pleural spaces and maintain comprehensive supportive therapy. The rupture commonly occurs at the inferior end—usually within 2 or 3 cm. of the cardia. It is usually a solitary longitudinal slit-like

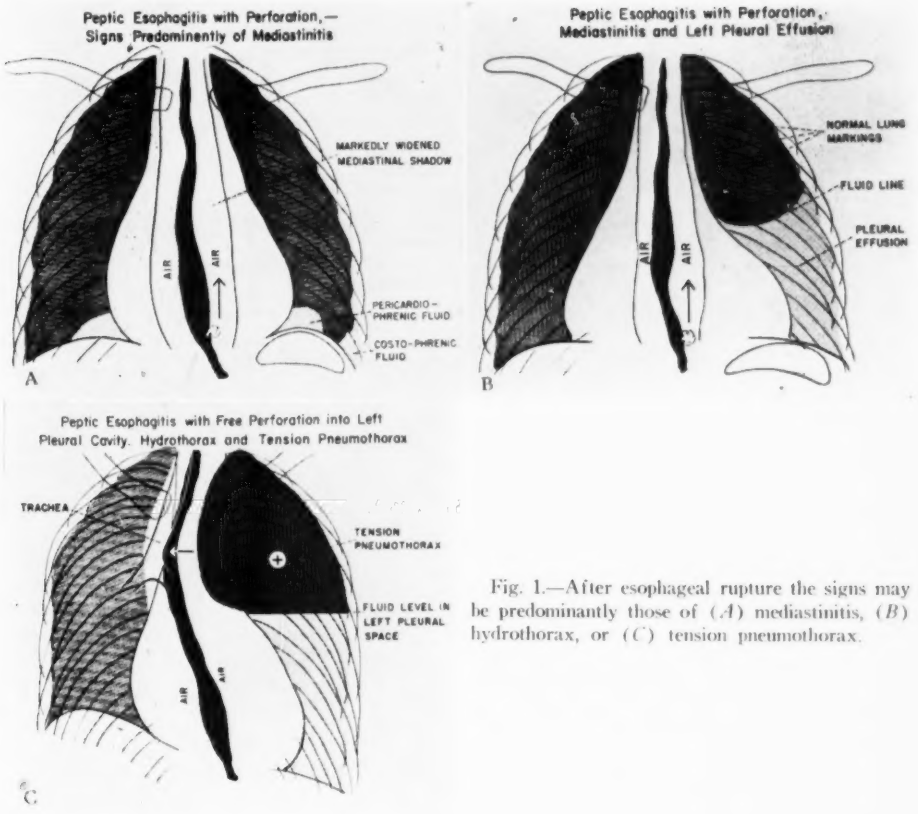


Fig. 1.—After esophageal rupture the signs may be predominantly those of (*A*) mediastinitis, (*B*) hydrothorax, or (*C*) tension pneumothorax.

opening. Dark discoloration of the adjacent area from bile and gastric juice is readily apparent. Attempt at closure of the perforation is practically always advisable, even though the condition of the patient is precarious. On the other hand, if the patient has survived the initial days without operative closure, surgical drainage of an involved pleural space may prevent a fatal outcome. When thoracotomy is definitely inadvisable, pleural drainage should be established if the process communicates with the pleural space.

Prior to operation, where feasible, a Levin tube should be passed carefully into the stomach and attached to a constant source of suction. This limits any further extravasation of gastroduodenal contents. The necessity for massive doses of antibiotics, nasal oxygen, and other supportive measures is apparent.

Entrance into the pleural cavity is usually through the bed of the resected seventh or eighth rib. Adequate mediastinal drainage is established at the site of the esophageal tear. The tear is exposed and repaired longitudinally in layers. No attempt is made to close the mediastinal pleura. The pleural cavity is lavaged with a copious amount of warm saline and the thorax closed in a routine manner. An adequate method of external pleural drainage is essential. The more frequently encountered postoperative complications include empyema, mediastinitis, and breakdown of the esophageal repair. The subsequent development of a stricture at the site of the repair is infrequent.

TABLE 1.—*Spontaneous Rupture*

Case	Year	Age, Yr.	Sex	Preceding Emesis	Pain			Shock	Dyspnea
					Onset Abrupt	Location	Severe		
1	1952	56	F	+	+	Lower chest	+	+	+
2	1955	62	F	+	+	Lower chest & shoulder	+	0	+
3	1956	3 days	M	+	—	—	—	+	+
4	1957	69	M	+	+	Substernum & back	+	+	+

Report of Cases

This report is based on nine cases of spontaneous rupture of the esophagus encountered at the Evanston Hospital from 1946 through 1957. In four of the patients the correct diagnosis was made and operative repair of the esophageal tear performed. All of these patients survived. In the remaining five patients the diagnosis of an esophageal rupture was established at autopsy. The majority of the patients were middle-aged. However, three were under the age of 5 years, and one surgical patient was only 3 days old. There was no significant sex difference.

Surgical Patients.—The 72-hour-old infant deserves special mention. This male child had an uncomplicated gestational period and birth. Twelve hours following birth he began to have intermittent regurgitation of bloody mucoid material. Increasing dyspnea and decreased breath sounds over the right chest prompted thoracic roentgenography. This revealed right hydropneumothorax (Fig 2*A*). Thoracentesis suggested the presence of gastroduodenal fluid. An esophagram showed extravasation of the medium into the area of the hydrothorax (Fig 2*B*). Catheter drainage of that pleural space was instituted on the second day after birth. There was continued drainage of gastric and intestinal juice from the catheter, and on the third day a right thoracotomy was performed. A 4 mm. right lower esophageal tear was repaired and external drainage of the right pleural space continued. There was no evidence of other esophageal disease that might indicate the etiology of the rupture. The postoperative course was uncomplicated, and esophagrams taken 12 days and one year later (Fig. 2*C*) were normal. Recurrent vomiting developed at 20 months of age, and an esophagram (Fig. 2*D*) showed a stricture at the site of the rupture. Esophagoscopy reveals gastric mucosa protruding through the stricture. The patient has responded well to dilations of the stricture. However, the presence of gastric mucosa suggests that another operative procedure may be necessary.

Of the remaining three patients who underwent operation, an episode of vomiting initiated an abrupt symptom onset in each. The etiology of the vomiting was not determined except in one woman, who later was found to have a gastric

TABLE 2.—*Spontaneous Rupture*

Case	Year	Age, Yr.	Sex	Preceding Emesis	Pain			Shock	Dyspnea
					Onset Abrupt	Location	Severe		
5	1946	25	M	+	—	—	—	+	+
6	1948	4½	M	+	—	—	—	+ Late	+
7	1950	54	M	0	—	—	—	+ Late	—
8	1955	50	F	+	+	Substernal, back & left shoulder	+	0	+
9	1955	1	F	+	—	—	—	+ Late	0

of Esophagus—Surgical Cases

Findings						
Chest	Abdomen	Chest X-Ray	Preop. Diagnosis	Operative Finding	Postop. Complication	Comment
+	0	+	Esophageal rupture	Left lower esophageal tear	Esophageal-pleural-cutaneous fistula	Associated malignant gastric ulcer
+	+	+	Esophageal rupture	Left lower esophageal tear	0	Biopsy showed chronic esophagitis
+	+	+	Esophageal rupture	Right lower esophageal tear	Esophageal stricture at 20 mo.	Ectopic gastric mucosa at lower esophagus
±	+	+	Esophageal rupture	Left lower esophageal	Small empyema	Preoperative chest film of major diagnostic aid

ulcer, associated with a carcinoma. Severe lower chest or substernal pain was present in all three patients, and two exhibited some degree of associated shock. Two had pain radiation: one to the left shoulder and one to the back. None had a temperature elevation above 100 F. Dyspnea was uniform, and all had positive physical chest findings, decreased breath sounds being most prominent. Two patients had epigastric guarding, and one of these had associated distention. One patient had only abdominal distention, and one failed to show any abnormal abdominal findings.

Thoracic roentgenograms revealed a unilateral hydrothorax in each instance (Fig. 3*A*, *B*). Mediastinal emphysema was readily visualized in one case, and this patient also exhibited the passage of swallowed iodized oil U. S. P. (Lipiodol) into the involved pleural space (Fig. 4).

A preoperative diagnosis of esophageal rupture was made in each of these four cases prior to thoracotomy. The tear was linear and at the inferior esophagus in each instance. In all but one case it was on the left.

The postoperative course was complicated by empyema in two cases. In one it resolved spontaneously, and in the other an esophagopleural fistula developed. This resolved after open drainage of the pleural cavity. There were no delayed complications except for an esophageal stricture, occurring at the age of 20 months in the infant who had an esophageal rupture during the early neonatal period.

Nonsurgical Patients.—Among these five patients there was only one whose history and findings closely paralleled those of the surgical patients. This patient, a 50-year-old woman, had abrupt onset of severe lower substernal and left shoulder pain after an episode of vomiting. The cause of the vomiting was not known. She was admitted four hours after symptom onset. There were some dyspnea, a moderate degree of shock, and diminished breath sounds over the left chest. A roentgenogram of the thorax revealed left hydrothorax, and the diagnosis of a spontaneous esophageal rupture was considered. Unfortunately, this diagnosis was not pursued when an iodized oil esophagram failed to show any extravasation of the medium. Her condition rapidly deteriorated, and she died 12 hours after admission. Blood-tinged, dark fluid, 550 cc., was aspirated from

of Esophagus—Nonsurgical Cases

Findings					
Chest	Abdomen	Chest X-Ray	Clinical Diagnosis	Course	Comment
±	0	—	Encephalitis	Died 3 hr. after admission	Left lower esophageal tear with left hydrothorax; delirium and vomiting during preceding 3 days
+	+	—	Ileal intussusception	Death within 48 hr. after correction of bowel obstruction	Left lower esophageal tear with left hydrothorax
Late +	0	+	Myocardial infarction	Died 21 days after admission; satisfactory progress until shortly before death	Lower anterior esophageal rupture with bilateral hydrothorax; acute esophagitis
+	±	+	Dissecting aneurysm	Neg. esophagram; died 12 hr. after admission	Left lower esophageal tear with left hydrothorax; acute esophagitis
0	0	—	Gastroenteritis	Repeated vomiting; died 8 hr. after admission	Lower posterior esophageal tear with bilateral hydrothorax; congenital internal hydrocephalus

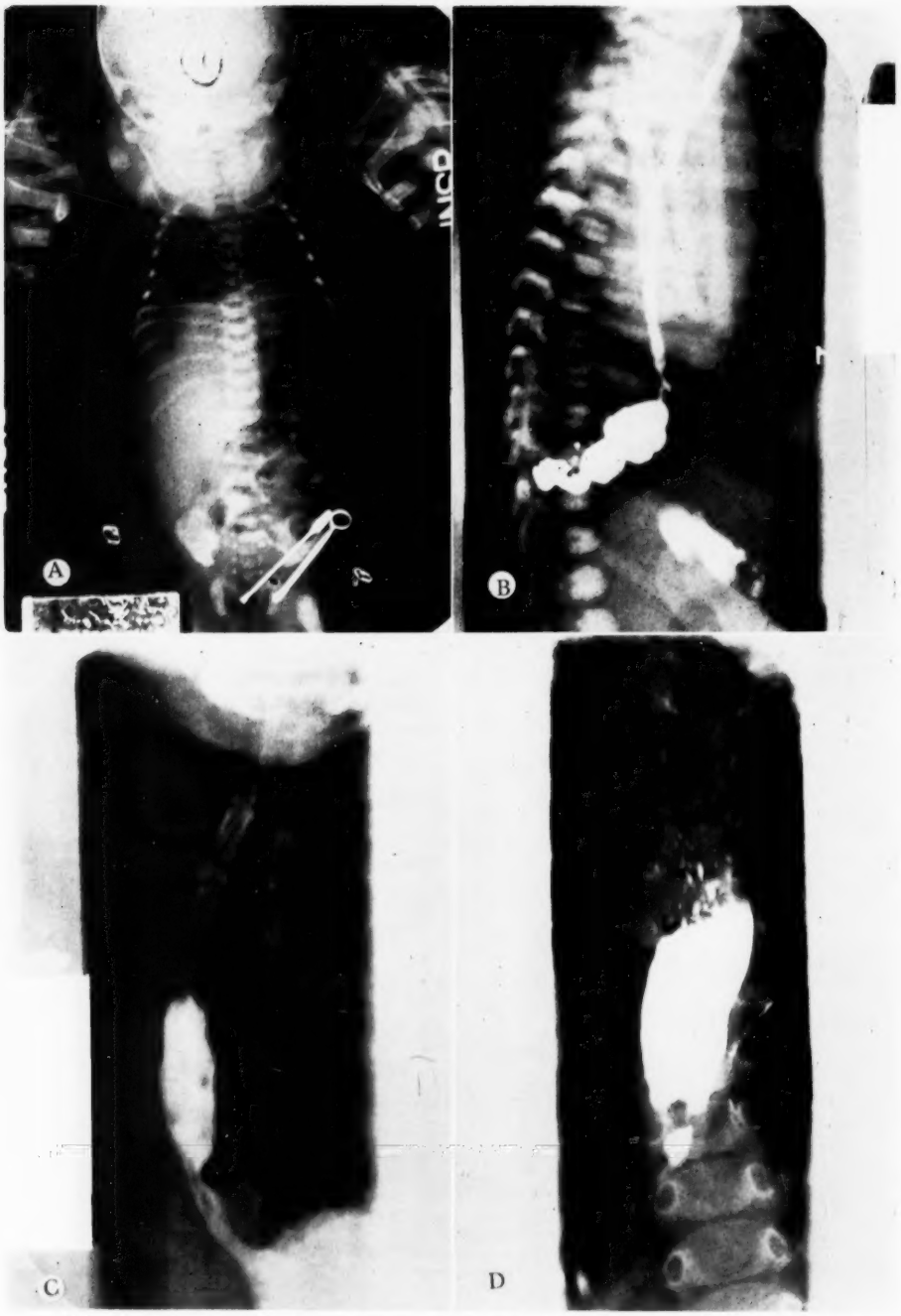


Fig. 2.—(*A*) Three-day-old infant with a right hydropneumothorax due to esophageal rupture. (*B*) Esophagram showing intrapleural extravasation of the medium. (*C*) Normal esophagram at one year of age. (*D*) Lower esophageal stricture at 20 months of age. Gastric mucosa seen at area of stricture.

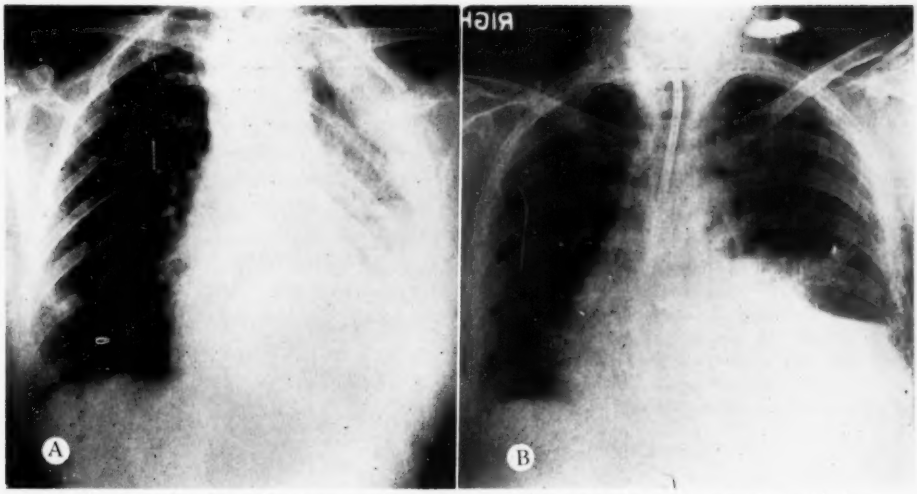


Fig. 3.—(*A* and *B*) Roentgenographic evidence of pleural effusion and mediastinal widening secondary to esophageal rupture.

the left pleural space shortly before death. Necropsy revealed a 2 cm. linear tear of the left lower esophagus with associated mediastinitis and a left hydrothorax. There was no evidence of chronic esophagitis.

Fig. 4.—Roentgenographic evidence of iodized oil (Lipiodol) extravasation at the site of an esophageal rupture.

One patient, a 4½-year-old boy, was admitted to the hospital with an 18-hour history of repeated vomiting and abdominal pain. Physical examination suggested an intestinal obstruction, and abdominal exploration was performed, with reduction of an ileal intussusception. In the immediate postoperative period he was febrile and confused, and continued to have intermittent vomiting. His condition became steadily worse with increasing shock. Death occurred on the second postoperative day. Decreased breath sounds were noted over the right chest on the day of death. Necropsy revealed a 1.7 cm. linear esophageal tear 2 cm. above the cardia on the right. There were adjacent mediastinitis and a 200 cc. right hydrothorax. Microscopically there was minimal evidence of any esophagitis.

Two patients had primary neurological disease. One patient, a 25-year-old man, was admitted in a moribund state. He had been delirious, with intermittent vomiting, for three days. Moderate shock, dyspnea, and fever, with a temperature of 102.4 F, were noted at the time of admission. Death occurred within three hours. A diagnosis of encephalitis was substantiated at necropsy. There was also a 2.5 cm. tear in the left lower esophagus and a 200 cc. dark-brown left hydrothorax. Microscopically there was evidence of acute esophagitis. The other patient, a one-year-old boy, had a congenital internal hydrocephalus. Intermittent vomiting of one day's duration prompted admission, with a diagnosis of gastroenteritis. The chest and abdominal findings were reported to be normal at the time of admission. The vomiting continued, and, although the child seemed to be doing well, he died abruptly, eight hours after admission. Necropsy showed a posterior rupture

of the inferior portion of the esophagus with gastric contents in both pleural spaces.

The last patient, a 54-year-old man, was admitted with a diagnosis of acute myocardial infarction, which was verified. One week after admission he had an episode of unexplained vomiting, without residual distress. Two weeks later increasing restlessness and shock developed, without a demonstrable cause. Examination revealed percussion dullness over both sides of the thorax, and a roentgenogram showed a bilateral pleural effusion. His condition continued to deteriorate, and he died 12 hours after the onset of the shock. Necropsy revealed a ventricular aneurysm at the site of the infarct. There was also a 0.5 cm. lower anterior esophageal tear with associated bilateral hydrothorax. Microscopically there was acute esophagitis, but no evidence of chronic esophageal disease.

Comment

Spontaneous rupture of the esophagus refers to those instances of esophageal perforation in which there has not been direct external trauma to the esophagus. These cases are delineated from the much larger group of esophageal perforations that are secondary to instrumentation. Anderson,[1] among others, has suggested that the term spontaneous is a misnomer, as an etiologic factor is frequently apparent. However, we feel that, although the term is not entirely correct, its almost uniform usage in preceding reports makes a change inadvisable.

The clinical manifestations of spontaneous esophageal rupture generally appear abruptly and usually are related to an episode of vomiting. The increased intraluminal pressure associated with vomiting apparently may exceed the bursting pressure of the esophagus. It is probable that a preexisting peptic esophagitis is often a predisposing factor. Eight of the nine patients in our series had episodes of vomiting in the period shortly before evidence of an esophageal tear. The majority of the patients are middle-aged, without a significant sex predilection. It should be noted that three of the patients were under the age of 5 years, and one was but 3 days old. This is the youngest recorded patient, to our knowledge.

A satisfactory history was obtainable in five of the nine cases. All but one patient had severe lower chest or epigastric pain. In two cases there was radiation of the pain —to the left shoulder in one and through to the back in another. One should consider an esophageal rupture when severe lower chest or upper abdominal pain appears after an episode of vomiting.

Some degree of shock was present in seven cases. This became progressively more profound, in spite of a normal or an elevated hemoglobin. The temperature remained below 100 F in all of our patients who survived. Moderate to marked dyspnea was usually present.

Physical examination disclosed positive findings in seven of eight patients. In one patient, who died soon after admission, the thoracic findings were equivocal. The usual abnormal features were diminished breath sounds and hyperresonance over the area of hydropneumothorax. Abnormal chest findings have usually been absent or minimal early in the course of the process. Abdominal guarding, tenderness, or distention was present in four of the six cases in which the examination was reported adequately. The guarding and tenderness, like the pain, were usually epigastric.

A roentgenogram of the thorax is of maximum aid in alerting one to the diagnosis of an esophageal rupture. Often there is a unilateral, fairly extensive hydropneumothorax on the side of rupture. Occasionally, the fluid collection is bilateral, if the rupture is so situated as to produce a bilateral pleural communication. Mediastinal emphysema, with or without cervical emphysema, may not be apparent but is of great diagnostic aid when present. A lateral roentgenogram of the chest may be of considerable aid in equivocal cases. Six of our patients had thoracic roentgenograms, and all showed evidence of fluid accumulation in the pleural space. In one instance it was bilateral. The diagnosis may be confirmed by roentgenographic demonstration of intrapleural extravasation of swallowed contrast medium. This procedure was positive in one of our patients. It should be emphasized

strongly that a negative result does not rule out an esophageal rupture. Such a finding in our series deterred pursuit of the proper diagnosis, and the patient died.

Aspiration of a hydrothorax, if present, will usually lead one to suspect an esophagopleural communication. Gastroduodenal fluid is readily recognized, and there may even be particles of food. Continuous external drainage of the hydrothorax should be instituted if thoracotomy is not possible.

Four of our patients had a correct preoperative diagnosis and survived after operative repair of the esophageal tear. Five of the patients were not operated on, and all died. Only one of these patients presented the usual history and findings associated with a spontaneous esophageal rupture. Unfortunately, in this instance, a negative esophagram proved misleading. One patient had an intestinal obstruction, and one had been hospitalized for a myocardial infarction. Two of the nonsurgical patients had primary neurological disease. One had an acute encephalitis, and the other had a congenital internal hydrocephalus. The frequency of the occurrence of esophageal rupture in patients with neurological disease suggests the validity of the Cushing hypothesis of ulcer formation.

Entrance is made into the thoracic cavity at the level of the seventh or eighth rib. The site of rupture is usually identified by its surrounding area of discoloration. If a Levin tube is not already in place, it may be inserted at this time. We feel that a two-layer closure of the esophageal tear, if possible, is advantageous. The defect in the mediastinal pleura is left open and the pleural space thoroughly lavaged. An adequate system of external pleural drainage is absolutely essential during the postoperative period.

Empyema, with or without breakdown of the esophageal repair, is the commonest postoperative complication. Two of our four surgical cases developed an empyema, though in one it was quite small.

We have encountered one late complication following operation. Three of the patients had subsequent esophagrams. Two were normal. However, the infant with the neonatal esophageal rupture developed a stricture at 20 months of age. Esophageal dilatations have relieved the symptoms and abnormal roentgenographic findings.

The role of chronic esophagitis, in predisposing to an esophageal tear, is difficult to evaluate. It has been noted infrequently in previous reports but may well have been overlooked. It was definite in only one of our nine cases. However, two instances of acute severe peptic esophagitis were found in our series. It is likely that esophagitis is a significant predisposing factor.

Conclusion

Spontaneous rupture of the esophagus is an acute surgical emergency. The rupture usually takes place during an episode of vomiting. An element of peptic esophagitis may be a predisposing factor. Initially, severe lower substernal, lower chest, or epigastric pain is prominent. There may be associated upper abdominal tenderness and guarding. Lower esophageal rupture should be considered in the evaluation of an acute upper abdominal syndrome.

The patient appears critically ill, and a moderate to marked degree of shock is common. Within a short time the features of mediastinitis, with or without associated hydropneumothorax, predominate. Their appearance roentgenographically substantiates the diagnosis.

Prompt thoracotomy, with closure of the rupture and adequate drainage of the pleural space, is the treatment of choice. Early recognition and treatment are essential if one is to reduce the morbidity and mortality of this condition.

This report analyzes data on nine cases of spontaneous esophageal rupture that occurred at the Evanston Hospital from 1946 through 1957. Four patients had an operative repair of the rupture, and all survived. The nonsurgical patients died.

636 Church St.

REFERENCES

1. Anderson, R. L.: Rupture of the Esophagus, J. Thoracic Surg. 24:369-388, 1952.
2. Barrett, N. R.: Report of a Case of Spontaneous Perforation of the œsophagus Successfully Treated by Operation, Brit. J. Surg. 35: 216-218, 1947.
3. Boerhaave, cited by Kinsella, T. J.: Spontaneous Rupture of the Esophagus, J. Thoracic Surg. 17:613-631, 1948.
4. Bunch, G. H., Jr.: Spontaneous Rupture of the Esophagus, Ann. Surg. 145:1001-1008, 1957.
5. Cushing, H.: Peptic Ulcers and Interbrain, Surg. Gynec. & Obst. 55:1-34, 1932.
6. Derbes, V. J., and Mitchell, R. E., Jr.: Rupture of the Esophagus, Surgery 39:865-888, 1956.
7. Derrick, J. R.; Harrison, W. H., and Howard, J. M.: Factors Predisposing to Spontaneous Perforation of the Esophagus, Surgery 43:486-489, 1958.
8. Eliason, E. L., and Welty, R. F.: Spontaneous Rupture of the Esophagus, Surg. Gynec. & Obst. 83:234-238, 1946.
9. Dorsey, J. M., and Kyser, F. A.: Perforated Peptic Esophagitis, Quart. Bull. Northwestern Univ. M. School 29:120-124, 1955.
10. Ferguson, D. J.; Sanchez-Palomera, E.; Sako, Y.; Clatworthy, H. W., Jr.; Toon, R. W., and Wangensteen, O.: Studies on Experimental Esophagitis, Surgery 28:1022-1039, 1950.
11. Graham, E. A.: Editorial Comment, Year Book of General Surgery, edited by E. A. Graham, Chicago, The Year Book Publishers, Inc., 1944, p. 382.
12. Harrington, S.: Personal communication to the authors.
13. Kinsella, T. J.; Morse, R. W., and Hertzog, A. J.: Spontaneous Rupture of the Esophagus, J. Thoracic Surg. 17:613-631, 1948.
14. Mackler, S. A.: Spontaneous Rupture of the Esophagus: Experimental and Clinical Study, Surg. Gynec. & Obst. 95:345-356, 1952.
15. Olsen, A. M., and Clagett, O. T.: Spontaneous Rupture of the Esophagus: Report of Case, with Immediate Diagnosis and Successful Surgical Repair, Postgrad. Med. 2:417-421, 1947.
16. Richter, H. M., Jr.; Davis, R. A.; Ruge, D., and Walter, N. T.: The Effect of Cortical and Subcortical Brain Lesions upon Gastric Secretion in Dogs with a Vagus-Preserved Total Gastric Pouch, S. Forum 7:524-528, 1957.
17. Samson, P. C.: Postemetic Rupture of the Esophagus, Surg. Gynec. & Obst. 93:221-229, 1951.
18. Weiss, S., and Mallory, G. K.: Lesions of the Cardiac Orifice of the Stomach Produced by Vomiting, J. A. M. A. 98:1353-1355, 1932.

DISCUSSION

DR. WILLIAM J. GILLESBY, Hines, Ill.: "Spontaneous," so-called, is a poor name for this condition, as it occurs in vomiting, particularly in our experience, with drunks. This is valuable because one can do a thoracentesis and find the methylene blue in the aspirate. Furthermore, when the chest is opened for repair, the methylene blue has outlined the rent very nicely, telling one where to sew the esophagus. We have avoided the use of a nasogastric tube because we believe it interferes with healing. At present we are using a Foley gastrostomy tube to avoid regurgitation of gastric juice up to the esophagus, thus delaying healing. We use one drop of methylene blue in an iodized oil (Lipiodol) swallow before the x-ray is taken.

DR. MICHAEL DORSEY, Evanston, Ill.: I would like to compliment Dr. Lynn on the manner in which he has presented our material. He has considered our experience at Evanston Hospital with perforation of the esophagus in the light of peptic esophagitis as an etiologic background for this condition. True enough, the first reported patients were, as Dr. Gillesby has said, in alcoholics with week-end or week-long binges, who vomited and went into shock and died; and, from them through the group in the neurosurgical services down to such infants as we encountered, these patients seem to bear out the contention that peptic esophagitis is the background process. Dr. Lynn did give credit to the men in the laboratory, who have shown the mechanical factors at work and have demonstrated that the esophagus, denuded of its strong mucosal and submucosal coat, is readily ruptured. Of course, peptic esophagitis does just that, namely, denude the esophagus. We are obligated to recognize early this condition and to treat it adequately, and we should obtain the same results as in perforations of the gastrointestinal tract otherwise, in view of the gratifying salvage rate.

DR. THOMAS E. LYNN, Green Bay, Wis.: I would like to thank Dr. Gillesby and Dr. Dorsey for their remarks.

Balanced Operations for Esophagitis Associated with Esophageal Hiatal Hernia

JACOB K. BERMAN, M.D., and EDWARD J. BERMAN, M.D., Indianapolis

The literature on esophageal hiatal hernia associated with esophagitis is voluminous. However, in reviewing the many early and recent articles on the subject, we have found that there is great confusion in nomenclature and very little consideration of the commonly associated lesions. There is also great variation in the methods of surgical treatment with equally variable results. This discussion concerns itself primarily with esophageal hiatal hernia, commonly known as the sliding or so-called short esophageal type.

Nomenclature and Pathogenesis

We shall use the term esophageal hiatus hernia to describe the so-called sliding or short esophageal type, and we define this as a cephalad displacement of the cardia of the stomach above the diaphragm (Figure, 1*A*). We have previously stated [4] that this particular type of hernia is primarily a malfunction of several of the derivatives of the foregut, the parts of the alimentary canal nourished mainly by blood from the celiac axis and concerned primarily with digestion. Therefore, in a significant number of patients there is an association of hiatal hernia with esophagitis, duodenal or gastric ulcer, biliary tract disease, and pancreatitis. Moreover, it is well to look upon the foregut derivatives as having a common mucous-gland system. When mucus in these organs is thick and viscid (mucoviscidosis), there is an association of sinusitis, bronchiectasis, and fibrocystic disease of the pancreas. This is also true in Kartegener's syndrome, and the common duct may be obstructed by thick, viscid mucus in the newborn. The reverse may be true when free and dissolved mucus is less abundant and less viscid. We have noted this in the association of tuberculosis and duodenal ulcer, pulmonary emphysema and duodenal ulcer, esophagitis and duodenal ulcer, cirrhosis of the liver and duodenal and gastric ulcer, and recurrent pancreatitis and gallstones, all of which may have a common origin in unprotected mucous membranes.[5,6]

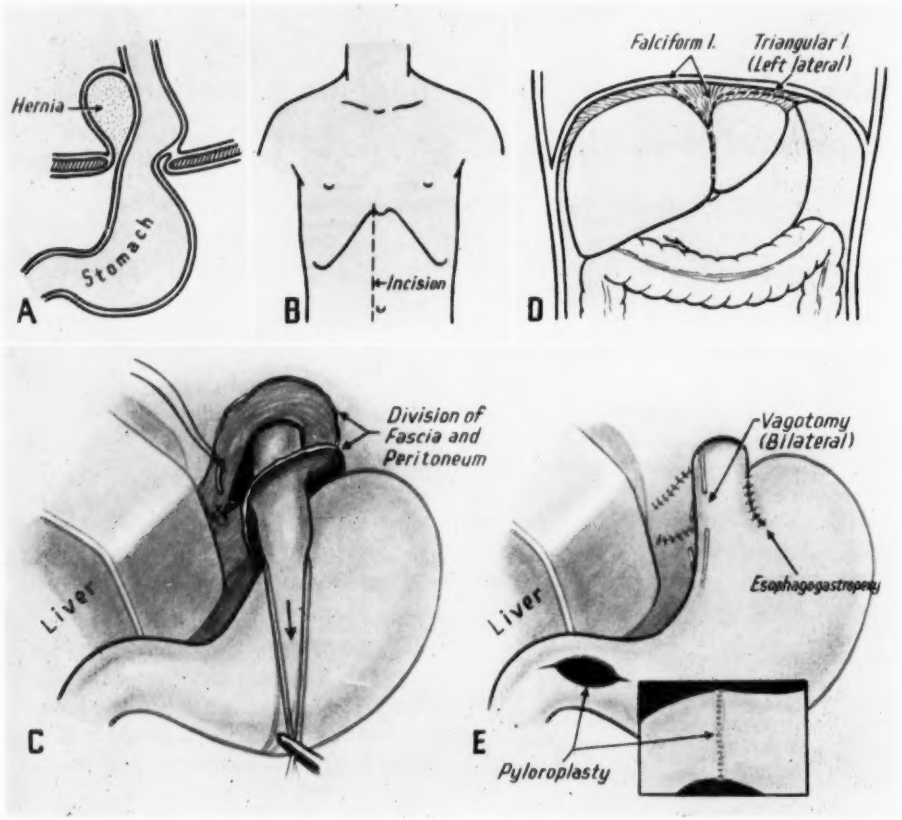
The treatment of esophagitis by balanced operations in paraesophageal, parahiatal, or rolling-type hernia, hiatal hernia en masse, and hiatal hernia with so-called true congenitally short esophagus will be discussed in forthcoming communications.

The etiology of the esophagitis in hiatal hernia is uncertain. However, most authorities ascribe the disease to two main causes: (1) a reflux of highly acid gastric juice, and (2) local tissue susceptibility.[3,7,13,16] The clinical history of pyrosis and regurgitation attests to reflux, as do cinematographic studies with barium. Although regurgitation may occur without hiatal hernia, it is surprising how rarely this phenomenon is observed on fluoroscopic examination, even in the Trendelenburg position, in the presence of a normal esophagogastric angle. No patient with esophagitis and without hiatal hernia has required surgery in our experience.

Local tissue susceptibility to peptic digestion is variable—perhaps due to the availability of mucin, as well as to something as yet unknown in the cells themselves.

From the Departments of Surgery, Indianapolis General and Methodist Hospitals.

Read at the 66th Annual Meeting of the Western Surgical Association, Rochester, Minn., Nov. 22, 1958.



(*A*) Diagram illustrates esophageal hiatal hernia, so-called sliding or short esophageal type.

(*B*) Abdominal incision is a right paramedian or midline incision, depending upon the habitus of the patient or associated disease. It is carried up to the chondrosternal juncture, and we do not hesitate to split the sternum to the left or the right of the xiphoid if necessary to gain adequate exposure.

(*C*) The left triangular (left lateral) and falciform ligaments are divided; the liver is depressed, and the left lobe is retracted to the right.

(*D*) The phrenoesophageal fascia (ligament) and peritoneum are divided, and the esophagus is surrounded with a ½ in. Penrose drain and pulled downward. The vagus trunks are tied and divided, and the separated fibers of the right crus or crura are approximated with interrupted 00 silk sutures.

(*E*) Esophagogastropexy has been performed, restoring the normal angle of the esophagus to the cardia. Pyloroplasty is then done by excising the anterior third of the pylorus and suturing transversely with an inner layer of 000 chromic gut and an outer layer of interrupted 000 silk. The phrenoesophageal fascia has been sutured down over the repaired crus.

Diagnosis and Progress of the Disease

Esophageal hiatal hernia may be asymptomatic. On the other hand, the history of patients with associated esophagitis is usually one replete with a long story of one or many of the following complaints: postprandial pain and discomfort, substernal burning (heartburn), dysphagia, pyrosis, dyspnea, anginoid attacks, regurgitation, aspiration with cough, particularly at night, vomiting, or hematemesis. For the relief of these symptoms, all of the patients herein reported have had a prolonged period of medical management, without benefit. One patient had also been subjected to two gastrostomies. We wish to underscore the fact, however, that only a small percentage of patients with esophagitis and hiatal

hernia need surgery, and therefore every patient should receive an adequate trial on medical management before any operative procedure is done. If the disease is refractory, if complications occur, or if associated lesions are present, surgery is definitely indicated.

Treatment

In attempting to relieve patients with hiatal hernia and esophagitis, we have tried various procedures advocated by different authorities,[1,2,8-12,14,15,17-20] but we have been unable to obtain consistently good results. Eight years ago we performed our first balanced operation. Our patient had esophagitis, pylorospasm, and high gastric acidity. (The gallbladder had been removed elsewhere prior to her admission to the hospital.) We felt we could not ignore any of these abnormalities and therefore, in one stage, performed a standard procedure for the cure of each. The patient remained well and without symptoms.

On the basis of the concept, then, that we were dealing with a disease of several derivatives of the foregut, which behave as a physiological unit, we finally decided to use a combination of procedures, viz., repair of the hiatal hernia, vagotomy, restoration of the cardioesophageal angle, and pyloroplasty.

We have called this operation "balanced" because it reestablishes a normal hiatus and a normal esophagogastric angle, with the added features of reducing gastric acidity and intragastric pressure, and facilitating gastric emptying. The esophagogastropexy not only restores the esophagogastric angle but increases the subdiaphragmatic gastroesophageal mass. This adds to the security of the repair. The technique follows.

A right paramedian or midline abdominal incision is made, depending upon the patient's habitus and associated disease (Figure, *B*). It is carried up to the chondrosternal juncture, and we do not hesitate to split the sternum to the left or the right of the xiphoid if necessary to gain adequate exposure. General exploration is carried out to determine the presence of associated disease. Next, the left triangular (left lateral) and falciform ligaments are divided so that the liver may be depressed and the left lobe retracted well to the right (Figure, *C*). The phrenoesophageal portion of the transversalis fascia is divided around the esophagus, and the hernia is reduced by pulling the esophagus downward, together with the peritoneal sac (Figure, *D*). The vagi are divided between clamps and tied. The esophagus is then pulled to the left and anteriorly so that the separated fibers of the right crus, or rarely the crura, of the diaphragm may be approximated medial and posterior to the esophagus, thereby closing the hiatus snugly. Esophagogastropexy is carried up far enough to restore the normal cardioesophageal angle. The posterior portion of the phrenoesophageal fascia, if well developed, is used to cover the suture line and buttress the esophagus, so that it stays in position and does not sag. The anterior third of the pyloric sphincter is excised, and the pylorus is sutured transversely (Figure, *E*). If there are associated lesions of the duodenum, biliary tract, or pancreas, they are corrected.

Statistical Survey

We have performed one-stage balanced operations in 19 consecutive cases of esophageal hiatal hernia (so-called sliding or short esophageal hernia) during the past eight years. The ages of the patients varied from 28 to 65 years; the average was 47 years. Eleven patients (58%) were women; 8 (42%) were men. All patients had been on medical treatment from 2 to 15 years; the average was 4½ years. Many had unrelated operations before the correct diagnosis was made. Three had gastrostomies and one a posterior gastroenterostomy. Esophageal dilatations and treatments by endoscopy were done in seven patients. Three of these patients were reported as having a very tight stenosis, refractory to dilatation; and yet cardiomyotomy was not

done in these or in any other of the cases in this series.

The diagnosis was established on clinical evidence and repeated flouroscopic and x-ray examinations, in addition to other tests, such as stomach acid determinations and repeated stool examinations for occult blood, to explain the secondary anemia. Esophagoscopy was done in 13 patients and on practically all patients operated upon during the past three years.

Associated foregut-derivative procedures were necessary in 10 patients (53%) and were as follows: Six had cholecystectomy for gallstones. Two required common-duct explorations for stones. One of these also had a stricture of the duct, which followed a cholecystectomy done in another city. The other had gallbladder, as well as common duct, stones and recurrent pancreatitis, requiring cholecystectomy, choledochostomy, and transduodenal sphincterotomy. One patient had a small cavernous hemangioma of the left lobe of the liver, which was excised. Three (16%) had scars of an old duodenal ulcer.

Our results have been uniformly good. There was no operative mortality. There has been no recurrence of herniation. Follow-up observation has been possible in all cases for periods varying from six months to eight years, with an average of two years four months. Only one patient still has complaints referable to the gastrointestinal tract. She was one of two patients who had eight previous operations, and she had been treated by a neuropsychiatrist. However, she is improving steadily now, 11 months after surgery, and is gaining weight. Esophagoscopy shows no residual esophagitis. None of our patients now require head elevation for sleep.

Summary

Esophageal hiatal hernia with associated esophagitis is a serious and persistent disease.

We believe that the disease is an expression of malfunction of several of the derivatives of the foregut; the diaphragmatic defect may well be of ancillary importance.

In attempting to remedy the malfunction, operations must be balanced so that there will be (*a*) a restoration of the normal position of the esophagus and stomach, (*b*) a normal esophagogastric angle (angle of His; plica cardiaca), (*c*) a reduction in hyperacidity, (*d*) a ready egress of gastric contents through a widely opened pylorus (relieving intragastric pressure), and (*e*) a correction of any associated disease of the foregut.

With this procedure we have obtained uniformly good results in a series of 19 consecutive patients, who have been followed from six months to eight years.

All patients except one have been relieved of their distressing symptoms. This patient is now improved and does not have esophagitis.

There has been no instance of recurrent herniation, and no patient has required further esophageal dilatation.

23 E. Ohio St. (4).

Addendum

Since this manuscript was submitted for publication nine additional patients with esophagitis and hiatal hernia have been treated with balanced operations. Clinical results to date have been excellent.

REFERENCES

1. Allison, P. R.: Reflux Esophagitis, Sliding Hiatal Hernia, and the Anatomy of Repair, Surg. Gynec. & Obst. 92:419-431, 1951.

2. Allison, P. R.: Observations on a Conservative Approach to Nonmalignant Lesions at the Cardia, J. Thoracic Surg. 32:150-164, 1956.

3. Barrett, N. R.: The Lower Esophagus Lined by Columnar Epithelium, Surgery 41:881-884, 1957.

4. Berman, J. K., in discussion on Effler, D. B., and Groves, L. K.: Short Esophagus, A. M. A. Arch. Surg. 75:639-646, 1957; Maurer, E. R., and Kierle, A. M.: The Serious Significance of Hiatus Hernia, ibid. 75:647-659, 1957, and Fisher, H. C., and Johnson, M. E.: Esophageal Hiatal Hernia: A Manifestation of Pepic Esophagitis, ibid. 75:660-669, 1957; pp. 670-671.

5. Berman, J. K., in discussion on Sieber, W. K.: Alimentary Tract Duplications, A. M. A. Arch. Surg. 73:383-392, 1956; Benson, C. D., and Linkner, L. M.: Surgical Complications of Meckel's Diverticulum in Infants and Children, ibid. 393-398, 1956; Condon, J. B., and Oberhelman, H. A.: Further Studies in Intussusception in Infants and Children, ibid. 73:399-406, 1956; pp. 407-408.

6. Berman, E. J.; Schneider, A., and Potts, W. J.: Importance of Gastric Mucosa in Meckel's Diverticulum, J. A. M. A. 156:6-7, 1954.

7. Berman, J. K.: Principles and Practice of Surgery, St. Louis, C. V. Mosby Company, 1950, pp. 822-823.

8. Burford, T. H., and Lischer, C. E.: Treatment of Short Esophageal Hernia with Esophagitis by Finney Pyloroplasty, Ann. Surg. 144:647-651, 1956.

9. Franklin, R. H.: Surgery of the œsophagus, London, Edward Arnold & Company, 1952, pp. 90-94.

10. Hafter, E.: Die Hiatushernie, Deutsche, med. Wchnschr. 82:1709, 1957.

11. Harrington, S. W.: Esophageal Hiatal Diaphragmatic Hernia, Surg. Gynec. & Obst. 100: 277-292, 1955.

12. Kempner, I.: The Transabdominal Repair of Hiatal Hernia, Surg. Gynec. & Obst. 106:549-554, 1958.

13. MacLean, L. D.; Perry, J. G.; Kelly, W. D.; Mosser, D. G.; Mannick, A., and Wangensteen, O. H.: Nutrition Following Subtotal Gastrectomy of 4 Types, Surgery 35:705-718, 1954.

14. Madden, J. L.: Anatomic and Technical Considerations in the Treatment of Esophageal Hiatal Hernia, Surg. Gynec. & Obst. 102:187-194, 1956.

15. Sherman, C. D., Jr., and Lyon, J. L.: Simplified Method for Esophageal Hiatal Herniorrhaphy, Surgery 43:857-860, 1958.

16. State, D., and Morgenstern, L.: The Inhibitory Role of the Pyloric Antrum on the Cephalic Phase of Gastric Acid Secretion in Dogs, Surg. Gynec. & Obst. 106:545-548, 1958.

17. Sweet, R. H.: Thoracic Surgery, Ed. 6, Philadelphia, W. B. Saunders Company, 1954.

18. Wangensteen, O. H.: Segmental Gastric Resection for Peptic Ulcer, J. A. M. A. 149:18-23, 1952.

19. Wangensteen, O. H.: Segmental Gastric Resection—An Acceptable Operation for Peptic Ulcer; Tubular Resection Unacceptable, Surgery 41:686-690, 1957.

20. Weisel, W.; Raine, F., and Watson, R. R.: The Efficiency of Esophageal Hiatal Hernia Repair, 104:471-474, 1957.

DISCUSSION

DR. JOHN VAN PROHASKA, Chicago: It is amazing that for so many surgical generations the multiple defects existing in hiatus hernia associated with esophagitis were treated by a simple closure of an enlarged hiatus ring. Let me emphasize the necessary correction in anatomical and physiological terms. The correction of esophagitis associated with hiatal hernia requires the reconstruction of the hiatus ring and the separation of the gastric content from the esophagus. In order to achieve this, the sling effect of the right crus of the diaphragm must be meticulously reconstructed. The wide gastroesophageal angle has to be corrected. This widened angle tends to open the esophageal stoma, so that in the act of breathing there is continual reflux of the gastric content between the stomach and the open esophagus. Dr. Berman's balanced operation corrects all of these defects. If the gastric content is prevented from reaching the esophagus, vagotomy, theoretically, may not be necessary. However, these patients often have an associated gastric retention due to malfunction of the pylorus. The retention in itself generates hypersecretion of the stomach. Therefore, pyloroplasty or some other drainage procedure is necessary. I would prefer a pyloroplasty. It may be assumed that an existing esophagitis would heal better if the gastric acidity were reduced. Since regurgitation is always feared, vagotomy would be desirable to abolish the cephalic phase of the secretion. Be that as it may, the importance of reduction of normal gastric acidity is debatable, because the esophagus is vulnerable to gastric content, even of low acidity. It depends more upon the constancy or the duration of the gastric reflux. A periodic reflux of short duration during the course of the day is negligible, but a constant reflux will produce esophagitis even if the gastric content is of low acidity. There is a considerable amount of experimental evidence that will support these data, as well as the vulnerability of the esophagus to bile and pancreatic juice.

Dr. Berman should be congratulated on his important contribution. I believe his operation is better than the severer procedures of jejunal substitutions or jejunal interpositions. These should be utilized only when the lower esophageal segment is so altered that it has to be resected.

DR. ALFRED M. LARGE, Detroit: I, too, should like to compliment Dr. Berman on this very logical and interesting approach to a rather difficult problem. Perhaps if we follow his ideas,

we may see a little less frequently the complicated and refractory case of esophagitis that bothers us so much.

With his permission, however, I should like to say a word about the management of these very refractory cases of esophagitis, for which the very multitude of operations that have been proposed act as mute evidence of the inadequacy of any one procedure. Surely we want to do the minor procedures before we do the very major ones; yet sometimes we have to think even of bypassing the entire stomach, or, as Dr. Van Prohaska says, of interposing a jejunal segment, or something like that.

I would like to give you our experience in Detroit in this connection with an operation that we have found to be very satisfactory. Some years ago Dr. Holt, one of our residents at that time, and Dr. Johnston became interested in this problem. At that time we had a number of patients who had had wide openings made in the cardioesophageal area for the treatment of cardiospasm. As we all know now, these people subsequently develop severe esophagitis. The concept in studying this problem was that bile or pancreatic juice, if it regurgitated, would be just as irritating to the esophagus as gastric juice; so they thought that one way in which to treat these people would be to do a distal gastric resection, a subtotal gastrectomy, a standard gastrectomy, if you will, but, instead of the ordinary type of gastrojejunostomy, to bring up a Roux en-Y loop of jejunum, 18 to 24 in. long, so that there could not be any regurgitation of bile or pancreatic juice up through the stomach into the esophagus. This was done on several patients, and the results were dramatic. These people, who were miserable and losing weight, were free of pain when they awakened from the anesthetic. To make a long story short, we now have 11 patients so treated, the longest follow-up being 7 years. The patients have all been either completely cured or markedly benefited. I would therefore like to suggest to you that when these really complicated cases of esophagitis occur, and when the patients do not respond to simple measures, you might like to consider the performance of a gastric resection, subtotal gastrectomy with a Roux en-Y loop gastrojejunostomy. If the esophagus itself is narrowed, you may have to do some local resection or plastic procedure as a first stage; but if the esophagus is open, this is not necessary.

Although this operation is a fairly extensive procedure, I think it is less extensive than the other big operations that have been done for esophagitis; it certainly has been very satisfactory and has stood the test of time in our hands.

DR. JOHN M. DORSEY, Evanston, Ill.: Whereas I am sure Dr. Berman has given credit in his paper to the workers in diaphragmatic hernia, when talking about diaphragmatic hernia, one has to genuflect a bit because of the basic work that Dr. Harrington did here. I am very happy to hear Dr. Berman talk about vagotomy in the repair of diaphragmatic hernia. I have heard men describe avoiding injury to the vagus nerve when repairing hernias. I have wondered why they made such a point of that. We were shown long ago that one of the ways by which to lengthen the esophagus is to divide the vagi. For instance, Francis Scrimger presented that work in dogs before the American Surgical Association in 1931. I think vagal division has helped in obtaining a sufficient length of esophagus in these patients, whose esophagus has been elevated a little through esophagitis or other processes, and that our repairs are better as long as attention is given to either a drainage operation, such as a pyloroplasty, or the adequate decompression of the stomach postoperatively.

The manner in which these patients have been handled through the abdominal approach and the ease which Dr. Berman has described is something that we are experiencing now with our improved anesthesia in abdominal surgery.

DR. JOHN T. REYNOLDS, Chicago: I should like to ask Dr. Berman how carefully he studied the gastric secretion in these patients before he decided whether they should have a vagotomy and drainage procedure. It seems to me the philosophy of their surgical approach is correct, but I have had two or three patients in whom we anticipated such a procedure, only to find that they had no acid whatsoever.

DR. JAMES H. GROWDON, Little Rock, Ark.: I think much of the confusion that exists in this problem is that it is not one entity but several. As long as we have incomplete knowledge not only of the cause of esophagitis but also of the way the sphincter mechanisms work between the esophagus and stomach, we shall continue to argue about various procedures that should be performed.

Mr. Allison has made us all aware that patients who have a sliding hiatal hernia are apt to have esophagitis. Perhaps this has been overemphasized. I find the symptoms of esophagitis and an actual esophagitis as seen through the esophagoscope may be very different. We are

often dealing with different conditions in relation to the type of surgical procedure to be performed best.

In routine esophagoscopy of our patients with a hiatal hernia, we find that even though they sometimes have severe symptoms of esophagitis, they may have no evidence of esophagitis as far as can be seen through the esophagoscope; on the other hand, some will. In our experience the vast majority of patients have had their symptoms well controlled by a simple repair of the hiatal hernia. When we are dealing with a more advanced type, or perhaps even a different type, of esophagitis, these multiple procedures which Dr. Berman has described may be of value, although I do not believe it is necessary to apply them in every case of hiatal hernia repair. It becomes more complex as one gets further into the problem. We have recently had a patient in whom at operation the lower esophagus appeared entirely normal externally, with the usual-appearing esophagogastric junction. On the other hand, we found that it was lined with gastric mucosa for a distance of 5 or 6 cm. above the presumed esophagogastric junction. We usually expect the transition from squamous to glandular epithelium to occur at about the point of insertion of the phrenoesophageal ligament onto the esophagus. We had no clue from external examination as to what we were actually dealing with. Whether a "blind" repair of the hernia with vagotomy plus a drainage operation would or would not help in this situation is a matter of conjecture.

Caution would indicate that every patient have an esophagoscopy and that the distance from the incisor teeth to the mucosal change be carefully measured. If the distance seems short, we are going to make it a policy now to open the stomach and explore the esophagus to determine the type of mucosa lining its lower segment.

Dr. Jacob K. Berman, Indianapolis: I have profited greatly from the remarks of those who have discussed our paper, and I am very grateful to them. I think Dr. Prohaska has given us one of the main features of the disease, namely, not the sudden spurt of strong acid once in a while, but the constant bathing of the mucosa in acid. That is the thing that causes the trouble. These people complain every day and night, every week, every month all year long.

Dr. Large's patients fit in with another group we are reporting which we have called hiatal hernia en masse. These patients have in effect a combination of hiatal as well as parahiatal hernia. This type occurs most frequently in patients who are obese and older. We had three patients in this group who required gastric resection for active complicated duodenal and gastric ulcers. We have not used gastric resections to control esophagitis since the advent of our balanced operations, even though we found three of our patients with old duodenal scars.

I thank Dr. Dorsey for mentioning Dr. Stuart Harrington, who was a pioneer in the abdominal approach in the surgical treatment of hiatal hernia. Dr. Dorsey also emphasized the fact that division of the vagi does lengthen the esophagus, so that it may be pulled downward more easily. The diagnosis of a short esophagus is usually an x-ray, and not an anatomical, diagnosis. We have encountered no case in which we could not bring the esophagus down.

Dr. Reynolds' question concerning gastric secretion is important. Yes, we have done gastric secretion studies, and, much to our amazement, we have found that we could not correlate symptoms with the degree of acidity. The quantity of secretion was more important; the patency of the cardia and its angle with the esophagus most significant. However, in this group all patients had what might be termed hyperacidity based on standard measurements. But we must remember it takes two to make a bargain. In the case of esophagitis, the "antigen," so to speak, is the acid, and the "antibody" is the resistance of the mucosa. I am sure you all know that alkaline digestive juices may also cause esophagitis. This is seen after total gastrectomy and esophagoduodenostomy.

It is true that there may be great discrepancy concerning what the endoscopist sees and what we actually hear in the way of complaints from the patient. However, in most cases the esophagoscopic findings are consonant with the clinical symptoms and the changes noted on x-ray examination, whether the disease is the stagnatory or the nonstagnatory type. In this connection I should emphasize that endoscopists are often reluctant to dilate the esophagus in these cases because they are afraid of rupturing it and producing some of the complications which Dr. Dorsey and his colleagues referred to. In three of our patients, as I stated, we

were told that the cardia was stenosed and could not be dilated without danger of rupture. We were advised that cardiomyotomy of the Heller type would be needed. This was not done in any of our cases, and none have needed dilatation.

Repair of the diaphragmatic defect alone will not cure these patients. We have tried this many times by the transthoracic, as well as the abdominal, route. The former is much easier, as has been emphasized many times. But we found that curing the hernia does not in itself alter the physiological mechanism which causes esophagitis.

Peptic Ulcer and Pulmonary Emphysema

WILLIAM SILEN, M.D.; WILLIAM H. BROWN, M.D., and BEN EISEMAN, M.D., Denver

Most surgeons are unaware that patients with pulmonary emphysema have an inordinately high incidence of peptic ulceration and that these ulcers are of a peculiarly complicated and resistant nature. This paper is a review of the incidence of peptic ulcer in our own Emphysema Registry, an investigation of gastric secretory activity in 20 patients with marked emphysema, and a study of pathogenic factors that may relate to the two conditions. The clinical implications of these findings are discussed.

I. Frequency of Coexistence of the Diseases

A. Incidence of Peptic Ulcer in Patients with Emphysema.—Green and Dundee,[1] in 1952, found a 19% incidence of ulcer in both a clinical and an autopsy series of patients with proved emphysema. In a similar study, Flint and Warrack[2] found a 21% incidence of peptic ulceration in 87 autopsy patients with proved emphysema, as compared with an incidence of 1.6% in a much larger series of nonemphysematous controls.

Supported in part by USPHS Grant No. H-3872.

Read at the 66th Annual Meeting of the Western Surgical Association, Rochester, Minn., Nov. 22, 1958.

From the Department of Surgery, University of Colorado School of Medicine, and the Denver Veterans Administration Hospital.

TABLE 1.—*Incidence of Peptic Ulcer in Clinical Series of Patients with Pulmonary Emphysema*

Author	No. of Patients with Emphysema	No. of Emphysema Patients with Ulcer	Incidence of Ulcer
Green and Dundee[1]	72	14	19%
Lowell and others[3]	25	6	24%
Latts and others[4]	479	74	15.4%
Silen	105	10 (20)*	10% (20%)*

* Symptoms of ulcer, but presence never proved.

TABLE 2.—*Incidence of Peptic Ulcer in Autopsy Series of Patients with Pulmonary Emphysema*

Author	No. of Patients with Emphysema	No. of Emphysema Patients with Ulcer	Incidence of Ulcer
Green and Dundee[1]	64	12	19%
Fulton[5]	42	8	18%
Latts and others[4]	107	29	27.1%
Flint and Warrick[2]	87	18	21%

Other studies supporting this thesis are summarized in Tables 1 and 2.[3-5] In general, peptic ulceration has been found to be at least three times as frequent in patients with emphysema as in nonemphysematous controls.

Among the 105 patients being carried on the Emphysema Registry of the University of Colorado School of Medicine,* we have found 10 with duodenal ulcer proved either by x-ray or by surgery. An additional 20 of these patients have significant gastrointestinal symptoms which suggest ulcer but have not had roentgoengraphic study.

B. Incidence of Emphysema in Patients with Peptic Ulcer.—The converse statistical study confirms the frequent coexistence of these two diseases. In a clinical and autopsy study of patients with duodenal ulcer, Hirvonen[6] found a 34% and 39% incidence of emphysema in an autopsy study of patients with benign chronic gastric ulcer. The incidence of emphysema in patients with peptic ulcer was two to three times that found in the nonulcerous controls studied by these authors.

* These carefully screened patients have been collected and are being followed by Dr. Roger Mitchell and Dr. Giles Filley in the Colorado Foundation for Research in Tuberculosis.

II. Characteristics of Peptic Ulceration Coexisting with Emphysema

In previous studies,[4] approximately 80% of the peptic ulcers found in patients with emphysema were located in the duodenum, a site distribution similar to that of ulcers not associated with pulmonary disease.

A. Explosive Occurrence of Complications.—Flint and Warrack[2] have pointed out the insidious progress and relatively asymptomatic nature of peptic ulcers in patients with emphysema, an impression strengthened by our own experience. Both the patient and the unwary physician may minimize the importance of upper gastrointestinal symptoms in the emphysematous patient, only to be overwhelmed by the sudden appearance of a serious complication of the ulceration. Both the dyspeptic symptoms and the subsequent weight loss may be ascribed by the physician solely to the emphysema and the possibility of peptic ulcer be overlooked. The following case demonstrates the insidious and asymptomatic nature of the peptic ulceration in an emphysematous patient.

CASE 1.—This 44-year-old truck driver had a long history of severe, crippling pulmonary emphysema, but during previous hospital admissions had not been noted to have symptoms of peptic ulcer.

He entered the Denver Veterans Administration Hospital in July, 1958, because of an abscess of the leg which required surgical drainage. At the time of admission it was found that he was anemic, with a hemoglobin of 9.9 gm. % and a hematocrit reading of 32%, as contrasted with hematocrit values of 52% and 55% on previous admissions. The stool was markedly positive for occult blood.

Eight days after admission, he developed mild dyspeptic symptoms, which had never been present previously. X-ray studies revealed a large gastric ulcer of the lesser curvature, from which he had apparently been slowly bleeding over a period of time, without gross melena or any other gastrointestinal symptoms.

Pulmonary function studies revealed evidence of advanced pulmonary emphysema, with a total vital capacity of 64% of predicted normal and a one-second vital capacity of 83%. A 12-hour nocturnal gastric secretion revealed a volume of 340 cc., with 38 degrees of total acid, amounting to 13 mEq. of total acid.

Despite blood transfusions and vigorous medical therapy, he continued to bleed very slowly from his gastric ulcer for three weeks. Suddenly, on Aug. 21, 1958, he had a sudden massive hematemesis, which precipitated severe shock. Three thousand cubic centimeters of blood was required prior to and during the operation (subtotal gastrectomy) which was necessary to control the hemorrhage. A tracheostomy was performed postoperatively to facilitate adequate pulmonary toilet and to diminish the pulmonary dead space. His postoperative course was satisfactory.

B. Medical Resistance of the Peptic Ulceration.—In previously reported series of cases of synchronous emphysema and ulcer, 40% to 60% of the patients had severe complications of the peptic ulceration.[4]

In our Emphysema Registry, to which patients are admitted solely because of the nature of their pulmonary disease, 10 of the 105 patients had proved peptic ulcer. Of these 10 patients, 6 had at least one major complication of their disease, such as perforation, major hemorrhage, or obstruction.

A case illustrating the remarkable resistance and complicated nature of such ulceration is cited.

CASE 2.—A 60-year-old man with a 20-year history of both progressive emphysema and proved duodenal ulcer was admitted to the Denver Veterans Administration Hospital on Nov. 8, 1957. Although medical measures had previously provided some relief of his ulcer symptoms, during the two months prior to admission the symptoms had become completely intractable, and he had a weight loss of 30 lb. For the three weeks before admission, he had intermittent crushing anterior chest pain associated with profuse diaphoresis.

Upon admission the classic physical findings of right-sided congestive heart failure and emphysema were present. The hemoglobin was 4 gm. %, with a hematocrit reading of 14%. This was quickly but cautiously corrected with blood transfusions, as the congestive failure was vigorously treated. An electrocardiogram revealed a recent evolving anteroseptal infarct. All possible medical measures were taken to treat his duodenal ulcer, and within three days his burning epigastric pain disappeared. Six days after hospital entry he suddenly developed signs of diffuse peritonitis. A perforated duodenal ulcer was surgically closed, using local anesthesia. For seven days postoperatively, despite all of the usual means of medical therapy, the patient had persistent upper gastrointestinal bleeding. One week following closure of the ulcer he had a sudden hematemesis, which required 3,000 cc. of

blood to maintain his circulatory volume. It was felt that gastrectomy provided the only chance for survival of this emphysematous patient, with cor pulmonale and a recent myocardial infarct, and a two-thirds gastric resection was carried out. The specimen revealed both the 2×3 cm. duodenal ulcer which had previously perforated and a 5×3 cm. antral ulcer, which was the source of the hemorrhage. Retained bronchial secretions and bronchopneumonia made tracheostomy a necessity. For 14 days following gastrectomy he seemed to be improving slowly, only to die suddenly of a fresh myocardial infarct, which was demonstrated at autopsy. A very early gastrojejunal ulcer was also found post mortem.

III. Emphysema as Complicating Factor in Treatment of Peptic Ulceration

Any coexisting systemic disease obviously will complicate the management of a patient with peptic ulcer. Certain characteristics of emphysema are particularly noteworthy, however, especially as they relate to the surgical management of these patients.

A. Anesthesia.—The problem of anesthesia in the emphysematous patient, although of tremendous clinical importance, is not germane to this discussion.

B. Tracheostomy.—Our experience has led us to employ tracheostomy extensively in the management of emphysematous patients who necessarily must undergo surgery for complications of peptic ulcer. This procedure is indicated to counter three physiologic defects in such patients.

1. Patients with emphysema have an increased physiologic dead space, as indicated by an increased functional residual capacity. Tracheostomy bypasses a considerable portion of this dead space, thus making optimal use of the elastic properties that still remain in the emphysematous lung.

2. Patients with emphysema frequently have an abnormal volume of bronchial secretions or chronic bronchitis, which, if not cleared, further encroaches upon an already minimal pulmonary reserve.

3. Patients with emphysema have great difficulty in expelling their bronchial secretions, especially in the postoperative period. Bronchotracheal suction via a tracheostomy is of obvious benefit in assisting in the removal of the pulmonary secretions.

C. Altered Response to Metabolic Derangements.—Patients with pyloric obstruction lose chlorides by vomiting and thus develop metabolic alkalosis. According to Randall,[8,9] any respiratory compensation to such alkalosis in the normal person occurs without detectable arterial oxygen desaturation. In patients with respiratory insufficiency, however, the respiratory compensation to metabolic alkalosis is sufficient to produce oxygen desaturation,[8,9] and even clinical cyanosis. Such a puzzling cyanosis occurring in a patient with emphysema and an obstructing duodenal ulcer is illustrated in the following case.

CASE 3.—A 51-year-old, markedly emphysematous man entered Denver Veterans Administration Hospital with a 10-year history of proved duodenal ulcer, including one episode of perforation. Despite medical therapy by his local physician, he had complete obstruction three days prior to hospital admission. On entry he had all the physical findings of emphysema but was markedly cyanotic as well. His blood pressure was normal, and he was not in shock. This puzzling cyanosis did not disappear with nasal oxygen therapy. His respiratory rate was 12 a minute. Serum electrolyte studies showed Na 124 mEq/L., K 3.7 mEq/L., CO_2 47 mEq/L. and chlorides 73 mEq/L. This severe cyanosis did not disappear until his marked metabolic alkalosis had been corrected by the administration of saline solution and potassium.

His obstruction was resistant to all medical means of therapy and required gastroenterostomy and vagotomy for ultimate cure. A 5 cm. chronic duodenal ulcer with penetration into the pancreas and transverse mesocolon was the cause of the obstruction.

IV. Possible Mechanisms for Coexistence of Peptic Ulcer and Emphysema

There is little objective evidence to support any of the numerous factors that have been suggested as producing peptic ulceration in patients with pulmonary emphysema.

A. Carbon Dioxide Accumulation.—Browne and Vineberg[10] found that secretion from a total gastric pouch in dogs varied directly with the carbon-dioxide-combining power of the blood and was independent of alteration in the blood pH.

They also noted that the gastric hypersecretion produced by vagal nerve stimulation was inhibited by hyperventilation but restored by raising the CO_2 content of the inspired air. Apperly and Crabtree [11] confirmed these findings in fasting men, noting direct correlation of gastric secretion with blood bicarbonate content, irrespective of alteration in the pH of the blood. They postulated that the elevated blood carbon dioxide content displaced chloride ions and made it more available for utilization in the production of gastric hydrochloric acid.

In a related fashion, Apperly [12,13] believes that the mild hyperventilation that occurs in tropical climates [14] produces a depression of the blood carbon dioxide content, and thus in some degree protects against hypersecretion of acid and ulceration. He cites for support the fact that the incidence of ulcer in the cool areas of North Queensland is four times as great as that found among ethnically similar peoples in the warm climates of Hobart, Tasmania.

In order to evaluate any possible causal relationship between blood carbon dioxide accumulation and peptic ulceration, the gastric secretion was measured in 20 patients with unequivocal pulmonary emphysema. In each patient a 12-hour nocturnal specimen was obtained by an indwelling gastric tube. The total gastric secretory volume and the free and total acid were then recorded. Two of these patients had duodenal ulcers and one a gastric ulcer. Two other subjects had symptoms suggesting ulcer, but in neither could an ulcer be demonstrated roentgenographically. The remaining 15 emphysematous patients had no gastrointestinal symptoms. The carbon-dioxide-combining power of the venous blood taken at the end of the 12-hour study of gastric secretion was determined in each of the 20 patients.

Eight of the twenty patients had a 12-hour nocturnal gastric secretion greater than 18 mEq. of free hydrochloric acid as the upper limit of normal. The two patients with proved duodenal ulcer were among the eight in this group, but the remaining six patients had no gastrointestinal symptoms. The acid values varied from 19.2 to 163 mEq., with a mean of 56 mEq. in this group. Twelve of these twenty emphysematous patients had 12-hour nocturnal gastric secretions less than 18 mEq. of free acid, including one patient with a proved gastric ulcer and two with ulcer-like symptoms. The acid values in this group varied from 0 to 11 mEq., with a mean of 4 mEq. of free acid.

The mean CO_2-combining power in the 12 emphysematous patients with normal gastric secretion was 28 ± 1.12 mEq/L. In the eight emphysematous patients with hypersecretion the mean CO_2-combining power was 31 ± 0.96 mEq/L. These figures are graphically illustrated in Figure 1. Their correlation with levels of gastric secretion is too low ($P > 0.1$) to indicate any causal relationship between the blood CO_2 content and the magnitude of gastric secretion.

B. Relationship of Severity of Emphysema to Gastric Secretion.—In the same 20 patients with emphysema, the relation of gastric secretion to the degree of pulmonary dysfunction as measured by the maximum breathing capacity was studied. The mean of the MBC based on percentage of predicted normal was $32\% \pm 4.9\%$ in the eight emphysematous patients with hypersecretion, whereas it was $49\% \pm 4.2\%$ in the 12 emphysematous patients with normal secretion. The difference between these groups is significant ($t = 2.44$; $P = < 0.05$ and

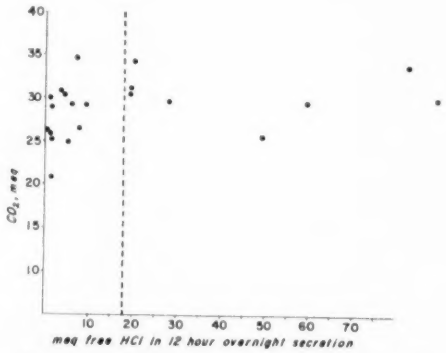


Fig. 1.—Relationship between carbon-dioxide-combining power and gastric secretion.

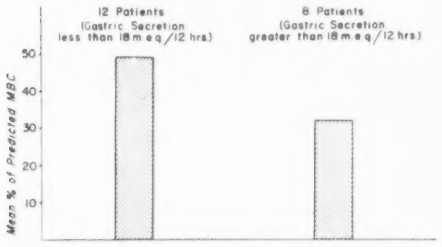


Fig. 2.—Relationship between pulmonary function and gastric acidity.

>0.01). The data are graphically illustrated in Figure 2. These results give further evidence that emphysema has a causal relationship to gastric hypersecretion but do not suggest a mechanism.

The mean total vital capacity of these emphysematous patients was 71% in both the normal and the hypersecretors. The mean one-second vital capacity was $57\% \pm 3.5\%$ in the 12 normally secreting emphysematous patients and $47\% \pm 8.2\%$ in the 8 hypersecretors. This difference is not significant ($t = 1.22$; $P > 0.10$).

C. Anoxia.—Van Liere [15,16] has shown that both the volume and the acidity of secretion from Heidenhain and Pavlov pouches of dogs decrease as atmospheric oxygen is reduced. Actual ulceration may be due to local mucosal hypoxia with subsequent diminished resistance to ulceration. It is unlikely that this is a significant factor in ulcer resulting from emphysema, since hypoxia is but a late complication of this condition—at least hypoxia as judged by arterial oxygen unsaturation.

D. Polycythemia.—The supposed frequent association of polycythemia and ulcer has been questioned by its own advocates. Wilbur and Ochsner,[17] for example, report an 8% incidence of ulcer in 143 patients with polycythemia vera, yet question the significance of their finding. Apperly and Cary [18] have shown in man and in dogs that either elevating or lowering the hematocrit will diminish gastric acidity. Thus, although polycythemia may occur in emphysema, this is probably of no significance in producing gastric hypersecretion or peptic ulceration, which seems to be associated with this pulmonary disease.

E. Coexistent Psychosomatic Factors.—The emotional response of patients to the crippling features of pulmonary emphysema has been suggested as a possible etiologic factor in producing peptic ulceration. Thus, according to Wolf and Wolff,[19] the hostility and resentment that frequently characterize the mood of the severely emphysematous patient result in gastric hypersecretion. Lowell [3] feels that the ulcer diathesis is accentuated by cigarette smoking, which, in turn, is frequently used as a mode of tension release in emphysematous patients. Gray [20] maintains that chronic anoxia in the emphysematous patient may produce stress, with an excessive adrenocorticotropic response and resultant ulceration. These hypotheses are attractive to contemplate but are unsupported by experimental fact.

IV. Clinical Implications

There is little doubt that there is an increased incidence of peptic ulcer in patients with pulmonary emphysema. The clinician must, therefore, be alert to the possible occurrence of peptic ulcer in the patient with emphysema, even in the presence of very minimal gastrointestinal symptoms. The explosive appearance of severe complications of ulcer in these people makes this high index of suspicion even more important, so that intensive therapy may be instituted as promptly as possible. The fact that peptic ulcer in the emphysematous patient is often so resistant to the usual forms of medical therapy and so disposed to the development of serious complications makes an aggressive therapeutic attitude mandatory on the part of both internist and surgeon.

Because patients with emphysema are generally poor surgical candidates and because the peptic ulceration seems to be of such an unrelenting nature, it would appear wise to liberalize the indications for surgery in this group of patients. Delay may not only fail to improve the ulcer but may make a difficult operative problem prohibitively

dangerous. If surgery is indicated, tracheostomy is often lifesaving, and should be performed when any question of respiratory insufficiency or troublesome secretions arises.

Whether or not improvement of pulmonary function will modify the ulcer diathesis in these patients is unknown. The underlying pulmonary lesion of emphysema is admittedly beyond either medical or surgical approach at the present time, but despite these considerations, all possible measures to improve pulmonary function should be utilized. These measures include control of pulmonary infection, the use of bronchodilators, the clearing of excessive secretions, and perhaps even the use of the respirator.

Summary

Patients with advanced pulmonary emphysema are predisposed to the development of resistant, and frequently complicated, peptic ulceration.

This study concerns 20 patients with proved pulmonary emphysema and a correlative evaluation of the relationship between the degree of gastric hypersecretion and factors which might produce this abnormality. It is shown that gastric hypersecretion is common in emphysematous patients, that such hypersecretion may not necessarily be accompanied by ulceration, and that such hypersecretion seems to occur more commonly in those patients with severer degrees of emphysema. No apparent relationship exists between venous carbon dioxide content of the blood and the gastric secretion.

On the basis of this clinical and experimental experience, it is suggested that patients with advanced emphysema be closely followed for the development of peptic ulceration and that surgical indications be liberalized in the management of such ulcers in order to avoid obligatory surgical intervention under less than optimal circumstances.

Department of Surgery, University of Colorado School of Medicine.

REFERENCES

1. Green, P. T., and Dundee, J. C.: The Association of Chronic Pulmonary Emphysema with Chronic Peptic Ulceration, Canad. M. A. J. 67: 438, 1952.

2. Flint, F. J., and Warrack, A. J. N.: Acute Peptic Ulceration in Emphysema, Lancet 2:178, 1958.

3. Lowell, F. C.; Franklin, W.; Michelson, A. L., and Schiller, I. W.: A Note on the Association of Emphysema, Peptic Ulcer and Smoking, New England J. Med. 254:123, 1956.

4. Latts, E. M.; Cummins, J. F., and Zieve, L.: Peptic Ulcer and Pulmonary Emphysema, A. M. A. Arch. Int. Med. 97:576, 1956.

5. Fulton, R. M.: The Heart in Chronic Pulmonary Emphysema, Quart. J. Med. 22:43, 1953.

6. Hirvonen, M., and Perttillä, M.: Frequent Occurrence of Pulmonary Emphysema in Patients with Gastric Cancer or Gastric Ulcer, Nord. med. 45:513, 1951.

7. Weber, J. M., and Gregg, L. A.: Coincidence of Benign Gastric Ulcer and Chronic Pulmonary Disease, Ann. Int. Med. 42:1026, 1955.

8. Roberts, K. E.; Poppell, J. W.; Vanamee, P.; Beals, R., and Randall, H. T.: Evaluation of Respiratory Compensations in Metabolic Alkalosis, J. Clin. Invest. 35:261, 1956.

9. Poppell, J. W.; Vanamee, P.; Roberts, K. E., and Randall, H. T.: The Effect of Ventilatory Insufficiency on Respiratory Compensations in Metabolic Acidosis and Alkalosis, J. Lab. & Clin. Med. 47:885, 1956.

10. Browne, J. S. L., and Vineberg, A. M.: The Interdependence of Gastric Secretion and the CO_2 Content of the Blood, J. Physiol. 75:345, 1932.

11. Apperly, F. L., and Crabtree, M. G.: The Relation of Gastric Function to the Chemical Composition of the Blood, J. Physiol. 73:331, 1931.

12. Apperly, F. L.: The Possible Influence of Climate on the Incidence of Peptic Ulcer in Australia, M. J. Australia 1:779, 1930.

13. Apperly, F. L.: Peptic Ulceration in Pulmonary Emphysema, Am. J. Digest. Dis. 1:270, 1956.

14. Sundström, E. S.: Contributions to Tropical Physiology, with Special Reference to Adaptation of the White Man to the Climate of North Queensland, University of California Publication in Physiology No. 6, Berkeley, Calif., University of California Press, 1926, p. 91.

15. Pickett, A. D., and Van Liere, E. J.: The Effect of Anoxia on Gastric Secretion from Pavlov and Heidenhain Pouch Dogs, Am. J. Physiol. 127: 637, 1939.

16. Van Liere, E. J., and Vaughan, P. E.: Basal Secretion of Pavlov Pouch Dogs as Influenced by Oxygen Want, Am. J. Digest. Dis. Nutrition 8:155, 1941.

17. Wilbur, D. L., and Ochsner, H. C.: The Association of Polycythemia Vera and Peptic Ulcer, Ann. Int. Med. 8:1667, 1935.

18. Apperly, F. L., and Cary, M. K.: The Relation of Gastric Acidity to the Erythrocyte Content of the Blood, Am. J. Digest. Dis. & Nutrition 3:466, 1936.

19. Wolf, S., and Wolff, H. G.: Human Gastric Function: An Experimental Study of Man and His Stomach, New York, Oxford University Press, 1947, p. 139.

20. Gray, S. J.; Benson, J. A., Jr.; Reifenstein, R. W., and Spiro, H. M.: Chronic Stress and Peptic Ulcer, J. A. M. A. 147:1529, 1951.

DISCUSSION

Dr. Jacob K. Berman, Indianapolis: I was surprised and happy when I learned that Dr. Silen and his colleagues were reading a paper on peptic ulceration and emphysema. I should like to read a paragraph from our manuscript which I didn't have time to read.

"It is well to look upon the foregut derivatives as having a common mucous-gland system. When mucus in these organs is thick and viscid—(mucoviscidosis)—there is an association of sinusitis, bronchiectasis, and fibrocystic disease of the pancreas. This is also true in Kartegener's syndrome, and the common duct may be obstructed by thick, viscid mucus in the newborn. The reverse may be true when free and dissolved mucus is less abundant and less viscid. We have noted this in the association of tuberculosis and duodenal ulcer, pulmonary emphysema and duodenal ulcer, esophagitis and duodenal ulcer, cirrhosis of the liver and duodenal and gastric ulcer, and recurrent pancreatitis and gallstones, all of which may have a common origin in unprotected mucous membranes."

This leads me to my comments, namely, that at the Sunnyside Sanatorium and at the Cold Springs Road Veterans Administration Hospital, in Indianapolis, the medical staff have observed exactly what Dr. Silen spoke about, namely, the frequent association of duodenal ulcer with tuberculosis and with emphysema. At first they thought it was due to drugs, particularly aminosalicylic acid U. S. P. However, patients not receiving irritating drugs also showed an unusual incidence of duodenal ulcer. Patients who have tuberculosis or chronic emphysema often complain of gastric symptoms. We must not be complacent about such symptoms and regard them as simply a part of the pulmonary disease. In so doing, we may overlook a hidden duodenal ulcer, which may perforate. It is equally important that we should not forget the lungs when we plan to do gastric surgery. We have had one patient with spontaneous pneumothorax after gastric resection for duodenal ulcer. A good clue in patients with emphysema is a high erythrocyte count and hemoglobin, where one might expect the reverse.

Dr. William Silen, Denver: I should like to thank Dr. Berman for his kind remarks. Perhaps we see more emphysema at Denver, and we certainly are impressed with the fact that we have seen a good deal more emphysema in Denver than in California. We have been struck with the difficult problems that these patients present, particularly the fact that they come in for something else related to their pulmonary problems or, in several cases, for completely unrelated symptoms, and then suddenly in the hospital, and even when on very intensive medical therapy, develop severe complications of peptic ulceration, which are extremely difficult to treat.

Use of Gastrostomy in Pediatric Surgery

LESTER W. MARTIN, M.D., and C. THOMAS FULTZ, M.D., Cincinnati

Present-day surgery has been perfected to a point where the mortality rate for most of the standard operations is practically nil, provided the patient is an adult in reasonably satisfactory physical condition. On the other hand, when the same type of operation is performed on newborn infants, the mortality figures frequently approach 50%. The infant differs from the adult in many ways: His physiology is different; his immunologic response is different; his disease is different; he frequently has other associated anomalies; he is smaller in size, and his nursing care must be much more constant and exacting. By reviewing the autopsy material and case histories and combining such information with the facts cited above, we are constantly modifying our surgical approach, to decrease further the operative mortality rate for this particular group of patients.

Vomiting, with aspiration of gastric contents, is well known to be one of the major immediate causes of postoperative death in infants undergoing major surgery, especially if an intestinal anastomosis is performed. Physiologically, an infant's cough reflex is poorly developed, and he cannot effectively clear material from the tracheobronchial tree. Immunologically, he has a poor resistance to any infection, aspiration pneumonia being especially severe because of his immature respiratory physiology. These infants, frequently premature, are further weakened by their disease plus a major surgical operation, and are especially susceptible to aspiration of gastric contents.

Read at the 66th Annual Meeting of the Western Surgical Association, Rochester, Minn., Nov. 22, 1958.

From the Surgical Service of Children's Hospital, and the Department of Surgery, University of Cincinnati College of Medicine.

The caliber of the indwelling nasogastric tube is limited by the small size of the infant's nostril plus the fear of a complicating purulent otitis media, so commonly seen in such infants. We must recall that the viscosity of the gastric contents is the same for infants as for adults, and therefore, ideally, the tube for infants should be just as large as for adults if it is to be effective.

To meet these various problems, it would appear that a No. 16 to No. 18 gastrostomy tube, to be left open at all times as a vent, would provide a satisfactory solution.

Material

Autopsy records from the Children's Hospital of Cincinnati were reviewed for a two-year period, from July, 1956. There were eight infants in whose postoperative death aspiration pneumonia played a major role.

During the past 14 months, a gastrostomy has been performed routinely at the time of surgery for 17 premature and newborn infants undergoing intestinal anastomosis or other major intra-abdominal or esophageal surgery. Eleven of these infants were premature. There have been no complications from the gastrostomy and no deaths in this series from aspiration, although six infants died of other unrelated causes (associated congenital heart disease, 3; sepsis, 1; "prematurity," 1, and interventricular brain hemorrhage, 1). Gastrostomy was performed in conjunction with the following procedures:

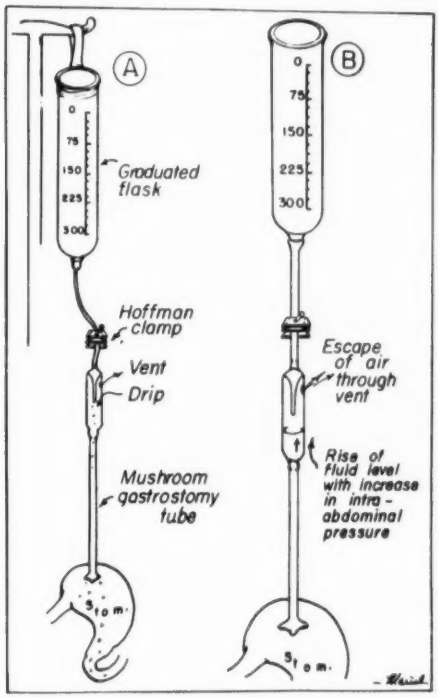
Duodenojejunostomy for duodenal atresia....5
Duodenojejunostomy for duodenal stenosis...3
Duodenojejunostomy for annular pancreas...1
Intestinal anastomosis for atresia.....3
Tracheoesophageal fistula 5

Comment

A Stamm-type gastrostomy has been used exclusively, placing the gastrostomy site at approximately the midportion of the anterior surface of the stomach, inserting a No. 16 or No. 18 mushroom-type catheter, and inverting the stomach edge with two purse-string sutures of 00000 silk. The

gastrostomy tube is then brought out through a stab wound in the left upper quadrant and the stomach sutured to the peritoneum above and below the gastrostomy site. When the gastrostomy is performed as an independent procedure, it is done through a 1.5 cm. incision over the midportion of the left rectus abdominis muscle, halfway above the umbilicus, separating the muscle fibers and delivering the wall of the stomach through the incision for placement of the catheter.

When the infant is returned to the incubator, the gastrostomy tube is left open at all times and allowed to drain. The infant's straining will force any gastric contents out through the tube. Suction should not be applied to the tube, as the opposite wall of the stomach will become engaged in the catheter, causing its obstruction and allowing vomiting. Gentle irrigation with 2 cc. of isotonic saline every two hours is beneficial in preventing mucus from obstructing the lumen.



A demonstrates the use of gastrostomy for feeding purposes. Note the Hoffman clamp *above* the vented drip apparatus.

B demonstrates the escape of air through the vent and the rise of fluid in the tube when an increase in intragastric pressure occurs, thus preventing vomiting.

Martin—Fultz

Feedings through the tube may be begun after 24–48 hours, employing a special glass drip apparatus which has an air vent at its top (Figure). Simple aspiration of the tube before each feeding will serve as an indication of whether the anastomosis is functioning and as a guide to the quantity of formula to be added to the stomach. Approximately 20 minutes should be allowed for each feeding. If during a feeding the intragastric pressure rises from overdistention or muscular contraction, the fluid rises in the glass as air escapes via the vent. This airway provides an outlet of less resistance than does the esophagus; thus material leaves the stomach via the tube rather than by vomiting. An x-ray of the abdomen of an infant cared for in this manner will reveal a complete absence of air in the intestine, thus demonstrating the effectiveness of the gastrostomy.

After the infant has sufficiently recovered from the operation, the tube is removed by simple traction, and the fistula seals within 24–48 hours.

The gastrostomy provides a very satisfactory means of feeding the premature infant, who is too small and too weak to take feedings by nipple.

Summary

On the basis of a limited experience, it would appear that gastrostomy is a valuable adjunct to major abdominal surgery in the premature and newborn group of infants, especially when an intestinal anastomosis is performed. It prevents vomiting and aspiration of gastric contents, provides effective decompression of the gastrointestinal tract, and allows a simple, efficient means for controlled postoperative feeding for this group of extremely fragile patients.

Department of Surgery, Cincinnati General Hospital.

REFERENCE

Gross, R. E.: The Surgery of Infancy and Childhood, Philadelphia, W. B. Saunders Company, 1953.

DISCUSSION

DR. E. LEE STROHL, Chicago: Our interest in temporary gastrostomy has been in patients at the opposite end of life's span—the aged patient. For some time we have used a gastrostomy for decompression in older patients undergoing abdominal surgery, where vomiting and distention are feared as postoperative sequelae. A No. 14 F. catheter is inserted into the stomach and brought out through a stab wound. At the point of exit of the catheter the stomach is tacked to peritoneum. We have not used a mushroom- or a bag-type catheter for fear of pressure necrosis to the gastric mucosa.

With Dr. Paul Holinger and Dr. Willis G. Diffenbaugh, of St. Luke's Hospital, Chicago, we recently collected the cases with complications of nasogastric intubation. We collected a sizable series and pointed out that the complications do not appear usually until six to eight weeks following the use of suction or feeding tubes (Strohl, E. L.; Hollinger, P. H., and Diffenbaugh, W. G.: Nasogastric Intubation: Indication, Complications, Safeguards, and Alternate Procedures, *Am. Surgeon* 24:721-729 [Oct.] 1958). For the same reasons that Drs. Martin and Fultz recommend gastrostomy in infants, it is our practice to use gastrostomy in adults, particularly in the aged patient undergoing abdominal surgery.

If we, as surgeons, continue to employ more and more tubes in the future, we may well be forced to paraphrase a discussion between Polonius and Hamlet, when Polonius asked Hamlet: "And what do you read, milord?" Hamlet replied: "Words, words, words." I think in the future we might well think of the nurse asking the surgeon: "What will you have, dear surgeon?" And his reply will be: "Tubes, tubes, tubes." [Laughter]

DR. GORDON K. SMITH, Los Angeles: I have enjoyed this paper very much. I arise to mention one or two things in relation to the Foley-type gastrostomy and to report a complication.

Actually, gastrostomy with tubes is not a new operation. From 1849 to 1876 numerous unsuccessful attempts to create gastrostomy in man were reported. Verneuil, after having admitted to 20 unsuccessful attempts, reported the first successful gastrostomy in 1876, attributing the result to the careful suturing of the visceral to the parietal peritoneum with silver wire. We believe that fusion of the visceral and parietal peritoneal surfaces is most important.

[Slide] We use a No. 16 or No. 18 Foley catheter and have found that the Gilbert attachment makes it very easy to bring it out through the abdominal wall.

[Slide] We then suture the visceral and parietal peritoneum together and hold the catheter in place on the abdominal wall with a Hesseltine umbilical clamp, bending it a little and putting a rubber tube on one side.

[Slide] This shows one of our gastrostomy tubes in place, with the wound exposed.

Since 1954, Dr. Ferris and I have done 188 of these operations. The next slide shows the cases in which it was done.

[Slide] We have had one serious complication. This slide shows the various types of tubes we have used, in addition to the Foley catheter.

One patient who had undergone vagotomy, pyloroplasty, and temporary gastrostomy had the tube removed on the fifth postoperative day. Forty-eight hours later the patient coughed while walking and had a complete dehiscence of the wound. This was repaired using through-and-through sutures. Following this the patient was able to return to an adequate oral intake; 18 hours later he went into shock and died. Autopsy showed extensive purulent peritonitis with a large amount of intraperitoneal fluid. Unquestionably, the gastrostomy contributed to this man's death.

It is our feeling that in secondary operations within the first two weeks after gastrostomy has been instituted, it should be reinstituted. In over 180 cases we have seen no evidence of pressure necrosis upon the gastric wall, as suggested by some workers. In our opinion the Foley catheter is a simple, convenient, and relatively safe method for temporary gastrostomy.

DR. WILLIAM J. GILLESBY, Hines, Ill.: Our use of the gastrostomy procedure began some four or five years ago in cases of esophageal resections to avoid putting a tube past the anastomosis. We began using gastrostomy tubes and found something very interesting.

The amount of secretion in the stomach with a nasogastric tube in place is between 600 and 1,600 cc. in 24 hours more than with a gastrostomy tube alone. The presence of the nasogastric tube stimulates the esophagosalivary reflex and produces by its very presence an average—and we ran this on some 14 cases—of 1,000 cc. of excess secretion. In other words,

the tube is not innocuous in the nose and esophagus; if you wish, the next time you have a patient with a nasogastric tube, you might watch him. He will be gulping 24 hours a day. He is actually producing, by his gulping and by the esophagosalivary reflex, 1,000 cc. more secretion than is ordinarily found in the stomach. We have used the flange Pezzer catheter, the T-tube catheter, and the ordinary catheter, and have had a couple of erosions which were not much of a problem. We abandoned the T-tube and Pezzer catheters and are using the Foley catheter with a 5 cc. bag. Having had gastric surgery myself in the last few months, and having requested a gastrostomy, I can tell you it is the greatest idea since the invention of 7-Up. [Laughter]

DR. LESTER W. MARTIN, Cincinnati: I have had no experience with the Foley catheter. We have used only the mushroom catheter. In that regard, we have been very careful to use a soft mushroom catheter rather than one that is very hard and firm, such as is frequently used for cystostomy.

Strictures of the Common and Hepatic Bile Ducts

A Study of More Than Four Hundred Operations, with One- to Twenty-Five-Year Follow-Up

WALTMAN WALTERS, M.D.; JAMES W. NIXON Jr., M.D.; THOMAS E. HODGINS, M.D., and JOHN A. RAMSDELL, M.D., Rochester, Minn.

In the past 34 years, up to Nov. 4, 1958, the senior author (W. W.) has operated on 429 patients with stricture of the common and hepatic bile ducts. Over the years repeated follow-up studies have been made by questionnaires or reexamination in the year of the study of the patients who survived operation. These have shown that 70% to 75% of the patients had continuing relief of biliary obstruction without recurrence of intrahepatic infection unless contraction of the anastomosis occurred.

Eight months ago (Feb. 13, 1958) we sent out questionnaires to the group who had undergone operation in the 10 years from 1943 through 1952, thus allowing an interval of at least 5 years between the operation and the study. Then we decided to see what the long-term results were; so we extended the date of inquiry an additional 10 years, from 1933 through 1942, thus making the follow-up period 5 to 25 years. In addition, we have obtained follow-up data on the patients operated on from 1953 through 1957; in this group the five patients who died at operation in these years were included in computing the results unless otherwise indicated.

This paper is a report of a study of 265 patients who had had 308 operations 1 to 25 years before the follow-up. It is of interest that stricture was due to surgical injury in all except 1 of the 265 patients studied; in the one exception it was due to external trauma to the abdomen.

The follow-up data will be reported in two series: In the first, Group A, the follow-up period was 5 to 25 years, and in the second, Group B, it was from 1 to 5 years. The purpose of the division into periods of time was to see what the long-term results were and to contrast the 5- to 25-year results with the 1- to 5-year results.

Group A consisted of 191 patients who had had 217 operations for stricture of the biliary ducts 5 to 25 years before this study and had replied to the questionnaires, or whose relatives had replied.

Group B consisted of 74 patients who had had 91 operations one to five years before the follow-up. There were 22 men and 52 women in this group.

For the patients in Group A (5- to 25-year follow-up) 30% of the 217 operations gave excellent results, 31% gave good results, 7% gave fair results, and 32% gave poor results (Table 1).*

In Group B (one- to five-year follow-up, with the 5 operative deaths excluded) 32 operations (37%) gave excellent results, 31 operations (36%) gave good results, 7 operations (8%) gave fair results, and 16 operations (19%) gave poor results (Table 1). The results of operations were about

Present address (Dr. Hodgins) London, Ontario, Canada.

Read at the 66th Annual Meeting of the Western Surgical Association, Rochester, Minn., Nov. 22, 1958.

Section of Surgery, Mayo Clinic and Mayo Foundation (Dr. Walters). Fellows in Surgery (Drs. Nixon, Hodgins, and Ramsdell), Mayo Foundation. The Mayo Foundation, Rochester, Minn., is a part of the Graduate School of the University of Minnesota.

* Hepaticostomies and miscellaneous operations are excluded.

TABLE 1.—*Over-All Results of Operations for Strictures of the Common and Hepatic Bile Ducts*

Results *	Group A, % of Operations †	Group B, % of Operations ‡
Excellent	30	37
Good	31	36
Fair	7	8
Poor	32	19

* Criteria for results are given in the text in the section "Results by Type of Operation."
† 5-25-year follow-up.
‡ 1-5-year follow-up.

the same for the two sexes. Four women in the group had pregnancies which went to term after operation; two of these were pregnant (one five months, the other three months) at the time of operation.

Many of the patients with good and excellent results have reported two or three episodes of cholangitis the first year after operation; these then disappeared. This observation is important, because if attacks continue or worsen, it means obstruction of the anastomosis, and further operation is usually necessary.

Results by Type of Operation

Results (Table 2) were considered (1) excellent when the patients reported good health, no chills, fever, or jaundice, and no pain or only occasional vague discomfort, seemingly not associated with the biliary tract; (2) good when the patient reported good health and one or more of the following symptoms only occasionally and in mild degrees: fever, chills, pain, and slight or only questionable jaundice; (3) fair when the patient had more frequent attacks of biliary obstruction, but was able to work, and (4) poor when one or more of the symptoms kept the patient from carrying on normal activities. The figures given in this paper for the most part are those for good and excellent results. In computing the results in Group B, all 91 operations were used.

Choledochocholedochostomy.—Choledochocholedochostomy was performed 48 times on patients of Group A, with 68% excellent or good results. It was performed 24 times on patients of Group B, with 83% excellent or good results and 17% (four) poor results.

TABLE 2.—*Results of Various Operations*

Operation	Total Operations	Excellent or Good Results, %
Choledochocholedochostomy		
Group A (5-25-yr. follow-up)	48	68
Group B (1-5-yr. follow-up)	24	83
Choledochoduodenostomy		
Group A	41	69
Group B	17	82
Hepaticocholedochostomy		
Group A	11	40
Group B	4	25
Hepaticoduodenostomy		
Group A	69	55
Group B	20	60
Double hepaticoduodenostomy		
Group A	17	65
Group B	6	50
Double hepaticojejunostomy		
Group A	3	100
Group B	3	66
Hepaticojejunostomy		
Group A	5	20
Group B	8	63

Choledochoduodenostomy.—Of the 41 anastomoses of the common bile duct to the duodenum on patients of Group A, 69% gave excellent or good results. Of the 17 anastomoses on patients in Group B, 82% gave excellent or good results, and 18% (three) gave poor results. It is interesting to note also that the results were so nearly the same whether the common duct was anastomosed to the common duct or to the duodenum.

Hepaticocholedochostomy.—Of the 11 single or double hepaticocholedochostomies performed on patients of Group A, 40% gave excellent or good results. Double hepaticocholedochostomy was performed once and single hepaticocholedochostomy three times on patients in Group B; excellent or good results followed in 25%, fair results in 25%, and poor results in 5%.

Hepaticoduodenostomy.—This operation was performed 69 times† on patients of Group A, and 55% of these operations gave

† A poor result followed a right hepaticoduodenostomy in one case.

excellent or good results. In Group B 20 such operations were performed, with 65% excellent or good results, 10% (two) fair results, and 25% (five) poor results. Two of the five patients who had poor results died in the immediate postoperative period.

Double Hepaticoduodenostomy.—Excellent or good results were obtained after 65% of the 17 operations performed on patients in Group A in which both the right and the left hepatic duct were anastomosed to the duodenum. This operation was performed six times on Group B patients, with 50% excellent or good results, 17% (one) fair results, and 33% (two) poor results. One of the patients listed as having a poor result died in the immediate postoperative period.

Double Hepaticojejunostomy.—Double hepaticojejunostomy was performed three times on Group A patients. All of these operations gave good results. In Group B good results were obtained from 66% of the three operations.

Single Hepaticojejunostomy.—Twenty per cent of the five anastomoses of one hepatic duct to the jejunum in Group A yielded excellent or good results, and in Group B 63% of the eight operations of this type gave excellent or good results and 37% (three) gave fair results.

The results of anastomoses of both hepatic ducts to the common duct or duodenum, we believe, are an achievement, since the stricture of the common duct was so extensive that the hepatic ducts had to be dissected from the liver to anastomose them to the intestine or to the common duct.

Hepaticostomy.—Mention should be made of the use of hepaticostomy in cases in which the extrahepatic ducts were completely strictured. Spontaneous internal fistulas developed in 8 (67%) of the 12 patients treated by hepaticostomy. Of these eight, three had later operations at which biliary-duodenal anastomoses were made; two of these had excellent results, and one, a poor result. Two of the eight have had excellent results following the development of the internal fistula and one a fair result. One died of liver dysfunction, and another, in seven years, of an unknown cause.

Of the remaining four, two died of liver dysfunction, one and seven years, respectively, after hepaticostomy. In the other two, external biliary fistulas developed, but both died of liver dysfunction, one and two years, respectively, after hepaticostomy.

In Group B hepaticostomy was performed two times. One patient died within six months, of hepatic failure. The other one is living, in reasonably good health, five years after operation and the development of an external biliary fistula.

In Group A, in three patients with complete strictures of the extrahepatic ducts, dilated intrahepatic ducts could not be found, and thus external biliary drainage was not obtained. A spontaneous internal fistula developed in one, and this patient has a fair result, 12 years later.

Multiple Operations.—Most of the patients operated on had had previous operations to correct the obstruction of the common or hepatic duct. In Group A, 26 patients had had four operations, and 11 had had five to eight operations ‡ for correction of the stricture previous to the time of operation by the senior author. The senior author performed two or more operations for stricture on 39 patients (20% of the patients in Group A); and of these 39 patients, 54% had excellent or good results, and 46% had fair or poor results (Table 3).

The senior author had operated previously for stricture of the duct on 17 patients (23%) in Group B; 9 (53%) had excellent or good results; 7 (41%) had fair or poor results, and 1 (6%) died in the hospital.

Regardless of the number of operations, results were as good as those in cases in which no previous repair of the stricture had been attempted when sufficient duct was present so that an accurate anastomosis could be established, and the liver did not show too great a degree of associated cirrhosis or hepatitis.

‡ These do not include the hepaticostomies.

TABLE 3.—*Multiple Operations Performed by Senior Author*

Two or More Operations	Group A	Group B
Patients	39	17
Per cent of group	20	23
Results, %		
Excellent or good	54	53
Fair or poor	46	47

Temporary Prosthetic Splints

Choledochocholedochostomy.—T-tubes were the most successful prostheses in this group (Table 4). They gave excellent or good results in 77% of the operations in which they were used on Group A patients, and catheters gave good or excellent results in 47% of the operations on this group of patients in which they were used. One good result was obtained when a Mayo-Sullivan tube was used,§ and one excellent result was obtained when a Vitallium tube was used. Prostheses were used for all operations on Group A patients.

In Group B no prostheses were used in three operations, and all gave good or excellent results. In 66% of the operations in which T-tubes were used results were excellent or good; moreover, in two operations in which the long Cattell T-tubes were used good results were obtained. Good or excellent results were obtained from 60% of the operations in which catheters were used.

Choledochoduodenostomy.—In the anastomoses of the common duct to the duodenum in Group A, 71% of the operations gave good or excellent results when a T-tube was used as a prosthesis, 56% gave good or excellent results when a catheter was used, and 62% gave good or excellent results when the Mayo-Sullivan tube was employed. For seven operations no prosthesis was used, and six of these gave good results and the other one a fair result. A polyethylene catheter was used in one operation which gave a poor result.

§ The Mayo-Sullivan tube had to be surgically removed at a later date, and the anastomosis was found to be satisfactorily patent.

TABLE 4.—*Use of Temporary Prosthetic Splints*

	Excellent Results, %*	
	Group A	Group B
Choledochocholedochostomy		
T-tube	77	66
Catheter	47	60 †
Mayo-Sullivan tube	‡	62
Choledochoduodenostomy		
T-tube	71	83
Catheter	56	—
Mayo-Sullivan tube	62	§

* Per cent of operations with prosthesis.
† Long Cattell T-tube in two cases; excellent results.
‡ Mayo-Sullivan tube and Vitallium tube used in one case each, with excellent results.
§ Used in six cases, with good results.

In Group B 83% of the operations gave good or excellent results when a T-tube was used. Results also were good or excellent from all six operations (100%) in which Mayo-Sullivan tubes were used and from three of the five operations in which no prostheses were used.

Hepaticocholedochostomy.—In the hepaticocholedochostomies in Group A excellent or good results were obtained in 50% of the cases in which T-tubes were used. A poor result followed the one operation in which a catheter was employed.

In the three in Group B in which T-tubes were used results were poor.

Hepaticoduodenostomy.—In Group A when anastomoses were made between the common hepatic duct and the duodenum, 42% of these anastomoses employing T-tubes, 43% employing catheters, and 73% employing Mayo-Sullivan tubes gave good or excellent results. When polyethylene tubes were used, 34% of these operations gave good or excellent results, and a Vitallium tube with a hepaticoduodenostomy gave a good result in one of the two cases. One of the two operations in which no prosthesis was used gave a good result.

In Group B when hepaticoduodenostomies were made, 67% of these operations using T-tubes, 33% using a catheter, and 71% employing a Mayo-Sullivan tube gave good

or excellent results. In one operation no prosthesis was used, but the patient died postoperatively; so late results are not available.

Double Hepaticoduodenostomy.—In Group A when both hepatic ducts were anastomosed to the duodenum, results were excellent or good in 63% of the operations in which T-tubes were used and in 83% in which Mayo-Sullivan tubes were used. Results were good from one operation and fair from one in which polyethylene tubes were used.

In Group B results were good or excellent from 20% of the operations in which T-tubes were employed. A good result was also followed in the one double hepaticoduodenostomy in which a Mayo-Sullivan tube was used. Prostheses were used in all of the anastomoses in both groups, but no catheters were used in Group B.

Double Hepaticojejunostomy.—In Group A double hepaticojejunostomy gave good results in all three instances in which it was used; the prosthesis consisted of a Mayo-Sullivan tube in one operation, polyethylene tubes in the second, and a Mayo-Sullivan tube and a catheter in the third.

In Group B this operation gave excellent or good results in two of the three times in which it was employed; T-tubes were used for two and a Mayo-Sullivan tube for one operation.

Comment.—It is interesting that in Group A no prosthetic devices were used in nine biliary-duodenal anastomoses and good or excellent results followed seven (78%). In Group B no prosthetic device was used in six biliary-duodenal anastomoses, and excellent or good results were obtained in 50% of them.

Late Postoperative Deaths

In Group A there were 28 deaths in the period of the follow-up, a mortality rate of 13% on the basis of 217 operations. In Group B there were seven deaths; five were immediately after operation. The causes of the five immediate postoperative deaths were uncontrollable intestinal bleeding, in two instances; liver failure, in two, and a pulmonary embolus, in one. Of the two late postoperative deaths, one was six months after operation, from hepatic failure, and the other, five years after operation, from a cardiovascular accident.

The 28 deaths in the Group A series occurred from 2 to 17½ years after operation (Table 5). Of these, seven were due to cirrhosis, nine to liver failure, and one to carcinoma of the uterus with cirrhosis. Three deaths resulted from cardiovascular accidents; two were cardiac deaths, and one was due to carcinoma of the lung. The cause of five deaths was unknown. Of the 16 patients whose deaths were due to either cirrhosis or liver failure, 6 had both hepatitis and cirrhosis at the time of operation, 4 had hepatitis, Grade 3 to 4; 4 had cirrhosis at the time of operation, and 2 appeared to have normal livers. One patient who died of carcinoma of the uterus had cirrhosis also at the time of death but had a normal liver at the time of operation.

Of the five patients in Group A who died of unknown causes, three had hepatitis and cirrhosis at the time of operation, while one had cirrhosis and one had a normal-appearing liver. Of the three who died of cardiovascular accidents, two had hepatitis, Grade 3, and one had hepatitis, Grade 2. More-

TABLE 5.—*Deaths in Group A Two to Seventeen and One-Half Years After Operation for Biliary Stricture*

Cause of Death	Deaths	Condition of Liver at Operation	Cases
Cirrhosis	7	Hepatitis and cirrhosis	6
Liver failure	9	Hepatitis, Grade 3 or 4	4
		Cirrhosis	4
		Normal liver	2
Cardiovascular accidents	3	Hepatitis, Grade 3	2
		Hepatitis, Grade 2	1
Cardiac failure	2	Hepatitis, Grade 3	1
		Cirrhosis	1
Carcinoma of lung	1	Normal liver	1
Carcinoma of uterus	1	Normal liver	1
Unknown	5	Hepatitis and cirrhosis	3
		Cirrhosis	1
		Normal liver	1
Total	28		

over, of the two who died of cardiac causes, one had hepatitis, Grade 3, and one had cirrhosis. The patient who died of carcinoma of the lung had a normal-appearing liver at the time of operation.

Summary

This is a follow-up report of results of 308 operations for stricture of the bile ducts performed by the senior author (W. W.) on 265 patients. Two series were studied; in the first, the follow-up period was 5 to 25 years, and in the second it was 1 to 5 years. The purpose of the division into periods of time was not only to see what the long-term results were but to compare the two groups.

In the long-term group, 191 patients, who had had 217 operations, replied to the questionnaire, and in the short-term group 74 patients, who had had 91 operations, were included. Approximately 20% of the patients had had two or more operations for stricture performed by the senior author.

Excellent and good results followed 61% of the 217 operations on patients having a 5- to 25-year follow-up and 73% of operations on the short-term group. Fair results were obtained in an additional 7% and 8%, respectively.

The results from choledochocholedochostomy (duct to duct) and from choledochoduodenostomy were practically the same in each series, with good or excellent results from 68% and 69%, respectively, in the long-term group, and from 83% and 82% in the short-term group. These operations made up the major portion of the operations, although hepaticocholedochostomy and hepaticoduodenostomy, both single and double, with single or double hepaticojejunostomy were performed in appreciable numbers of cases with almost equally good results, even in the 30 cases in which it was necessary to dissect out both hepatic ducts from the liver parenchyma in order to anastomose them to the duodenum or jejunum. The best results in general followed the use of T-tubes as prosthetic devices left in the anastomosis from six to nine months.

Of the 52 women in the short-term follow-up group, 4 had pregnancies that went to term after operation. One of these women was five months pregnant and another was three months pregnant at the time of operation.

Many of the patients with good and excellent results have reported two or three episodes of cholangitis the first year after operation; these then disappeared. This observation is important, because if attacks continue or worsen, it means obstruction of the anastomosis, and further operation is usually necessary.

It is of interest that stricture was due to surgical injury in all but 1 of 265 patients studied; in the one exception it was due to external trauma to the abdomen.

Late deaths were due largely to severe cirrhosis with and without hepatitis present at the time of operation or to unrelated causes, such as cardiovascular lesions.

Section of Surgery, Mayo Clinic.

DISCUSSION

DR. ALFRED M. LARGE, Detroit: This tremendous experience with stricture of the duct that Dr. Walters and his associates have had, I am sure, will be of great benefit to all of us in our management of these difficult cases. I should like to compliment Dr. Nixon as well on his presentation of this material.

Perhaps the controversy about whether we should make our anastomosis to the duodenum or to a Roux-Y loop of jejunum is less active nowadays than it was a few years ago. Perhaps the reason for it is that either method is safe. Dr. Walters, of course, has always preferred anastomosis of the strictured duct to the duodenum. Dr. Cole, Dr. Reynolds, and others have preferred the Roux-Y type of anastomosis. In our own limited experience with this problem, both in the laboratory and with our patients, we have grown to feel in the last few years that the type of operation is not quite as important as the way in which it is done. We think—as I am sure most of you do—that careful muscosa-to-mucosa approximation without tension is the most important feature in these reconstructions. If this can be done more easily and

more satisfactorily to the duodenum than to the jejunum, fine; if the other way around, fine; but we feel that the anastomosis without tension, and preferably over a T-tube, is the important thing.

I should like to make one other comment. In the occasional case in which these anastomoses are done for strictures, perhaps due to pancreatitis or other conditions in which the gallbladder has not previously been removed, it is important that, even though the gallbladder is normal, it be removed at the time the duct is anastomosed to the duodenum or jejunum; otherwise, cholecystitis and stones are almost certain to develop, necessitating a second operation.

DR. WALTMAN WALTERS, Rochester, Minn.: I agree with Dr. Large. The points he has brought out are very important, particularly the last one. I have had to remove the gallbladder in four or five cases in which biliary-intestinal anastomoses had been made previously. In these cases the anastomoses had been made for obscure types of pain, and frequently for obscure and uncertain types of chronic inflammation of the pancreas, which may or may not have been present.

I haven't a great deal to add to the statistical data that Dr. Nixon has presented. It seems to me that the thing I have learned from these cases is to keep searching for the remains of the common duct beyond the stricture. If even a drop of bile can be seen in the hilus of the liver when the duodenum is dissected from the undersurface of the liver, it will pinpoint the duct above the stricture. Then a probe can be inserted into the duct. Then, after the opening in the duct is enlarged a bit, the duct can be grasped with Allis forceps; and if the dissection is kept close to the duct or ducts, proximal portions can be dissected from the parenchyma of the liver. I am sure that the continuing search has played an important role in the increasing number of cases in which I have been able to find uninvolved duct and make a hepaticointestinal anastomosis. In the early series which I reported, from 1924 to 1947, I could not find the upper end of the duct in about 17% of the cases, but now that percentage in my series has been reduced to about 7%.

It is important to be sure that there are no stones in the intrahepatic ducts before the anastomosis is made, for frequently stones are there. It also is important, if one is going to anastomose the ends of the duct together, to be sure that there are no stones in the ampulla, and that the lower end of the duct is in reality the lower end of the duct, and not a mucus-lined fistula leading into the wall of the duodenum.

The use, fate, and results of retained prosthetic tubes within the common and hepatic ducts are interesting. My colleagues, Drs. McGoon and Clagett, collected 52 cases from the Clinic in which the stricture was high and an end-to-end ductal anastomosis was made over a Vitallium tube. Although it was necessary to remove these Vitallium tubes from 69% of the patients because they became obstructed with bile pigment and debris, 56% of the patients in the entire group had good results. I think that is a result well to remember.

I hope Dr. Reynolds, and perhaps Dr. Cole (I am not sure whether he is doing the anastomoses now without splints; at least I heard that Dr. Reynolds is), will have an opportunity sometime, maybe in the discussion, to present the results of their operations without the use of tubes splinting the anastomosis. I wish I knew whether to use them in all cases or in some cases, and in which cases to use them; also, if I do use tubes, how long to leave them. Certainly, the advantage of the T-tube is in the irrigation of the duct, and in that way the tube can be kept open and the duct can be kept free of muddy, stony material. With an inlying tube, a Mayo-Sullivan tube, or a catheter within the duct, florantyrone (Zanchol), as advised by Dr. J. M. McGowan, has proved its merits, not only experimentally but clinically as a cholagogue and also as a diluent of some of the material in the duct.

In my last remarks, I should like to speak about the biliary-duodenal anastomosis, which I prefer. The reason is that if one keeps the dissection close to the liver, no matter how many previous operations have been done, one can usually approach the hepaticoduodenal ligament without even opening the general peritoneal cavity and can effect the anastomosis. Under these circumstances, if there is leakage of bile or bleeding, it comes to the outside and does not go into the general peritoneal cavity. This is a simpler and safer operation than bringing a loop of jejunum up for the anastomosis, and the results of the two types of operation are about the same. In fact, in one series comparison of the results of the two procedures showed that the biliary-duodenal anastomosis was superior.

DR. JOHN T. REYNOLDS, Chicago: I certainly agree with everything Dr. Nixon and Dr. Walters have said. The only thing I would like to emphasize is the great importance of

continuing to operate upon these patients, even if they develop a recurrence of the stricture. Since they do not have a malignant disease, if we can do an anatomically correct operation, a large percentage should get well. I am sure Dr. Walters will agree that the patients with the worst results have been those who have come late, who have been neglected and have had repeated operations, inadequate drainage, stones in the duct, and chronic disease for a long period of time. His admonition against leaving stones in the duct certainly is necessary; one can irrigate out most, if not all, of the stones if one makes an effort to do so.

The success of the anastomosis depends upon being able to dissect up the proximal duct to such an extent that one can really operate upon it, and upon being very certain not to anastomose through scarred and fibrotic tissue. One really should cut off such fibrous tissue so that a good mucosa-to-mucosa approximation can be secured. We have always made a special point in the difficult cases actually to find the hepatic artery and dissect it out, being sure of where it was before we proceeded to expose the end of the hepatic duct carefully.

I have not used internal splints at all for quite a while and, although I have not nearly had the number of cases that Dr. Nixon and Dr. Walters have had, in the last three or four years we have had no reason to regret leaving internal splints out. I have had several patients in whom we left an internal splint which did not pass. In these we have had to redo the anastomosis because of the fibrosis which developed at the site of the suture. We felt that the presence of a prosthesis, covered by that time with a heavy encrustation of bile salts, had contributed to the redevelopment of the fibrosis. Any leakage which occurs about an anastomosis is slight in quantity and can usually be well removed through a small tube on which a low suction is placed. Usually this stops in three to four days.

Dr. James W. Nixon Jr., San Antonio, Texas: I am honored to have had the opportunity to present this paper for Dr. Walters. I wish to thank the discussers for their excellent discussion of this problem—a problem that is of much interest and that oftentimes is a serious one to deal with surgically.

Freedom from Pain After Hemorrhoidectomy

An Operative Technique and Results

WILLARD BARTLETT, M.D., St. Louis

As the attention of the surgeon is increasingly directed to bolder exploration into viscera which have hitherto seemed forbidding, we must not become complacent about our performance in familiar fields. That the record in regard to hemorrhoidectomy is far from ideal is attested to by the lengths to which patients go to put off the evil day.

There have been no papers on this subject on the program of the Western Surgical Association since, at least, 1941; yet the majority of anorectal operations will continue to be performed by general surgeons during the foreseeable future. In my opinion, neither the proctologic specialist nor the general surgeon can inflict the irreducible minimum of postoperative pain on his patient by following the conventional techniques of hemorrhoidectomy.

Dissatisfaction with such tedious convalescence led me in 1938 to make a critical review of the accepted techniques. It became clear at once that many surgeons were violating all the principles of wound healing adhered to in other fields. Application of clamps to tissue which is not to be excised, use of suture lines in a contaminated field, employment of any but the finest, most quickly absorbed material for ligature unnecessarily increase the minimum of edema and thrombosis in the tissues. Here, as elsewhere, the swollen wound is the painful wound. Moreover, the mass excision of skin (or mucosa) with underlying veins grasped in pedicle clamps makes impossible the accurate excision of all varicosities, and residual dilated veins undergo immediate thrombosis and are a source both of postoperative edema and of "recurrence."

Conventional techniques overlook the important component of postoperative pain due to sphincter spasm. The published plans of stretching or dilating the sphincter are often thought of having only the objective of increasing exposure in the operative field. I would add that there is also the very important factor of inducing *fatigue* of the sphincter under anesthesia in order to make it incapable of going into spasm for a day or two after operation.

Adherence to the principles of inducing sphincter fatigue and accurate excision of all varicosities, whatever their arrangement, with individual ligation of all vessels and the avoidance of suture lines, is time consuming. Operation can rarely be accomplished in less than one hour. Yet the surgeon must face the question of whose interest is best served if he employs the technical "short-cuts," for which the patient pays a bitter price in pain and delay in convalescence.

Since their introduction, the nonabsorbable sulfonamide drugs have regularly been used in the preparation of the field for elective operative procedures. Their employment assures the smoothest possible healing of wounds in the anorectal field but does not protect the patient against the painful consequences of a less than ideal operative technique.

Technique

Figures 1 and 2 present in diagrammatic form the pertinent details of the surgical

From the Department of Surgery, St. Louis University School of Medicine.

Read at the 66th Annual Meeting of the Western Surgical Association, Rochester, Minn., Nov. 22, 1958.

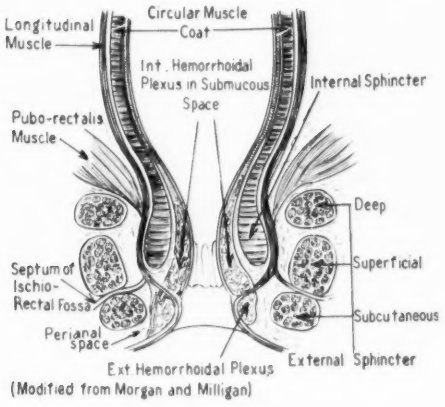


Figure 1

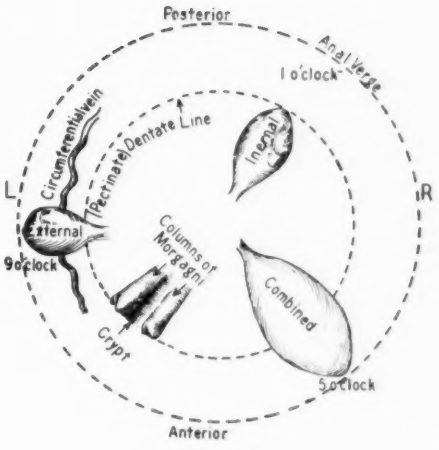


Figure 2

anatomy. Various monographs give excellent verbal descriptions. In the surgical illustrations, the patient lies in the "jackknife" position. It is essential that the hip joints be accurately centered over the "break" of the table, that the head and legs be lowered equally to make an included angle of 90 to 135 degrees, and that the knees be in extension. The analgesia of choice is caudal. It is assumed that proctosigmoidoscopy has previously been carried out in elective cases. The steps in the operative procedure are as follows:

1. Analgesia having been induced and the perianal skin disinfected and draped, a bivalve speculum is introduced and the condition of all structures about the dentate line carefully noted.

2. A gauze tape is introduced through the speculum to produce venous congestion, and Allis forceps are applied successively to the perianal skin of each external or combined hemorrhoid as the tape is slowly withdrawn.

3. Final identification of the hemorrhoidal masses is made by inserting a retractor (such as the Sims) and moving it progressively around the quadrants. Distal traction is made, in turn, on each Allis forceps, and a Pean forceps grasps the upper pole of each mass for countertraction.

4. A black silk "marking suture" is inserted and tied next to each Allis forceps (Fig. 3*A*) in order that the chosen point for the external angle of each incision may not be obscured by later manipulation.

5. Fatigue of the sphincters is then induced (all forceps having been removed) by the reinsertion of the bivalve speculum and separation of its blades to a width of 2.5 to 3 cm., approximately the diameter of a large, normal stool. The muscle is thus distended moderately for 10 minutes against the speculum; after withdrawal of the instrument, the sphincters will not often grasp two apposed fingers of the surgeon.

6. In order to prevent soiling of the operative field by fecal discharges, a conventional

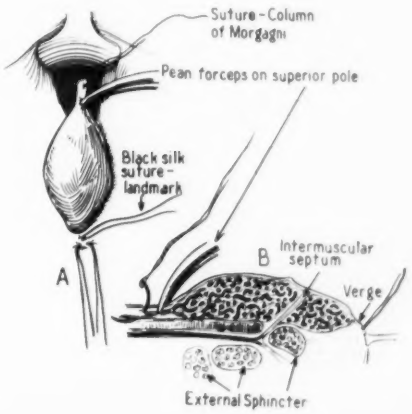


Figure 3

folded gauze square, 4×4 in., is rolled or folded to make a cylinder and a length of stout surgical gut tied securely about its middle. This "captive" pack is introduced into the lower rectum and the long ends of the ligature allowed to hang out beyond the anal verge. Gauze squares otherwise unsecured in the rectum may work upward and be nearly impossible to retrieve after operation.

7. The most dependent hemorrhoid in the field is usually attacked first, a blade retractor being used to hold away the opposite portion of the field (Fig. 3*A*). Distal traction by forceps on the upper pole puts the column of Morgagni (in a combined hemorrhoid) on tension.

8. This affords the best opportunity to place a suture-ligature around the artery and vein in the pedicle of the hemorrhoid, two successive "bites" being taken with 000 plain surgical gut on a fine Ferguson intestinal needle to the depths of the submucous space (Fig. 3*B*). The ends are securely tied, cut long, and held upward for future use.

9. The rather narrow elliptical incision through which excision of varices is made is now outlined (Fig. 4) well up on the sides of the hemorrhoidal mass; the area of skin to be removed is smaller than the area of the underlying veins.

10. The depth of the incision must be extended in its distal portion to the roof

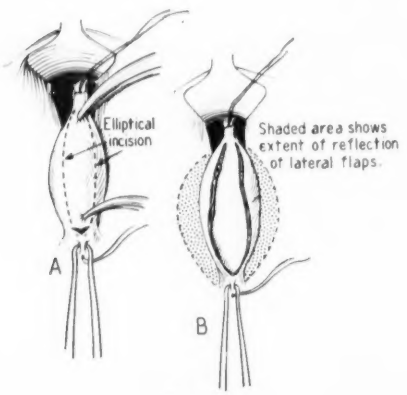


Figure 4

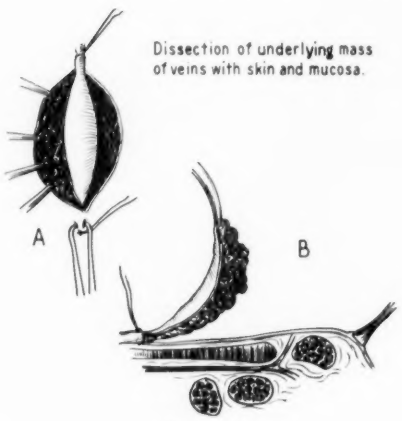


Figure 5

of the perianal space, which is a thin, fibrous layer of variable thickness coming off the longitudinal layer (Fig. 3*B*), overlying the external bundle of the external sphincter and inserting into the perianal skin. The lateral skin and mucosal flaps are dissected off the underlying veins (Figs. 4*B* and 5*A*), pushing the latter toward the covering ellipse as they are recognized.

11. A pedicle smaller than a lead pencil should remain when the Pean forceps on the mucosa of the upper pole is approached. Division of the mucosa and veins above the forceps completes the elliptical incision; the remaining submucosa tissue is picked up and encircled by the long ends of the suture ligature.

12. Any remaining components of a circumferential (external) vein must now be dissected out from under the flaps. The margins of the wounds should not quite fall into apposition.

13. The silk "marking sutures" are removed from the perianal skin; the rectal pack is withdrawn, and the wounds are lightly frosted with sulfanilamide crystals. No wick or drain has been left in the anal canal in recent years; bleeding will quickly appear externally, the sphincter being unable to occlude the anus in the first few hours. The intergluteal cleft is snugly packed and light compression applied until the first postoperative day.

After-Care

The patient takes a full liquid diet and rises to void on the day of operation, and receives a low-residue diet on the first postoperative day. Acetylsalicylic acid with codeine (32 mg.) is ordered and given upon the request of the patient, with the explicit direction that morphine or another strong analgesic be given within 20 minutes if relief is not obtained. Dextro propoxyphene hydrochloride (Darvon), in equivalent dosage, seems equally effective and less likely to induce nausea or prolonged constipation.

Removal of the compression dressing on the first postoperative day reveals the lines of the perianal skin to be free of visible swelling. Simple cleansing with water and cotton sponges is carried out thereafter. These wounds should be treated "dry" and require no dressings, discharge being minimal. Full ambulation is encouraged after the day of operation. If there has been no stool after 48 hours, a dose of bethanechol (Urecholine) chloride or magnesia magna (milk of magnesia) is effective; enemas are not given. Succinylsufathiazole (Sulfasuxidine) is given for 7 to 10 days.

Discharge from the hospital is usually effected on the fourth or fifth postoperative day, and the patient is seen at weekly intervals for three weeks, the gloved finger being gently passed on these occasions. Proctoscopy is done in six weeks, by which time there should be complete healing of all structures. The patient is asked to return in one year for reexamination.

Three features of hemorrhoidectomy, as commonly performed, seem particularly objectionable. First, leaving large triangular defects in the integument to facilitate "drainage of wound discharges" creates large wounds, which can heal only by granulation. The method of operation which I advocate creates little dead space; wound discharge is minimal, and there is no impediment to external drainage. Second, suture of some portion of rectal mucosa to a more distal position is not always done with accuracy in a distorted field, and too often produces an ectropion. Once hemostasis has been assured, proximal retraction of the upper pole (the pedicle) of an internal hemorrhoid is welcomed. Finally, dividing the fibers of the external bundle of the external sphincter for the sole purpose of decreasing postoperative pain is to be condemned. It may be an effective way of obscuring the complications of an unrefined technique.

Postoperative Events

Among the last 50 consecutive patients, 23 of them male, who underwent hemorrhoidectomy as the principal procedure, several had such anorectal complications as mucosal prolapse (2), acute thrombosis in one or more hemorrhoidal masses (3), fissure (5), and fistula (2). Other operations done simultaneously were ligation of the major saphenous trunk, conization of the uterine cervix, perineorrhaphy, and excision of the urethral caruncle. It is not thought that the performance of these coincidental operations added importantly to the patients' discomfort, although this consideration probably was influential in the decision to give morphine or meperidine (Demerol) initially to certain of these patients, rather than the combination of weaker analgesic drugs—acetylsalicylic acid, 5 or 10 grains (0.3 or 0.6 gm.), plus codeine, 32 mg.

During the 20-year period of adherence to the described technique, the intention has been to order postoperatively only acetylsalicylic acid and codeine orally, with the provision that morphine sulfate, 10 to 15 mg., or meperidine hydrochloride U. S. P., 75 to 100 mg., be given hypodermically if relief is not obtained within 20 minutes. As is evident in Table 1, this program has not always been carried out. In 6 of the 11 patients given morphine initially, this medication was administered by the attending nurse in disregard of the written order for a trial of acetylsalicylic acid plus codeine. In three other cases, an initial order for morphine or meperidine was written by me or the house officer for no reason that is

TABLE 1.—*Use of Morphine Sulfate or Meperidine*

None given		39
Morphine or meperidine given (only on day of op.)		11
Without trial	6	
Ordered directly	3	
For relief	2	
2 doses required	2	
1 dose given	9	
After operating day		
No analgesic	3	
Acetylsalicylic acid+codeine	6	
No data as to acetylsalicylic acid+codeine	2	

TABLE 2.—*Patients Receiving No Morphine*

Patients given no morphine		39
No analgesic	10	
Acetylsalicylic acid+codeine, 32 mg. on op. day only	10	
1 dose	9	
2 doses	2	
After op. day	16	
1 dose	8	
2 doses	2	
3 to 7 doses	6	
No data as to acetylsalicylic acid+codeine	3	

clear in reviewing the record. When given initially as the analgesic drug (26 patients, Table 2), acetylsalicylic acid plus codeine failed to relieve the patient and required a drug supplement in only 2 of 28 cases (Table 1). It is significant that, for whatever reason, the stronger drugs were given on the day of operation (Table 1); none was required thereafter.

It is equally striking that 10 patients (Table 2) did not ask for any analgesic, and that of 10 patients receiving acetylsalicylic acid plus codeine only on the day of operation, 9 asked for a single dose only. These patients were not heroes. Three of them were among thirteen of the patients noted in the record as being subject to chronic tension and apprehension phenomena. Most of these patients appeared in the group who continued to request analgesics into the third or forth postoperative day.

The need for catheterization of the bladder (Table 3) is rather obviously influenced by the administration of strong analgesic drugs more than by the discomfort resulting from hemorrhoidectomy; the two patients (Table 1) who were given morphine after failure of acetylsalicylic acid plus codeine to relieve pain did not require catheterization. If one subtracts the number of patients (five) who were given morphine without prior trial of codeine plus acetylsalicylic acid from the total of eight who were catheterized up to 36 hours, only in three patients of the entire series with otherwise normal ability to void can the need for catheterization be laid solely to the performance of hemorrhoidectomy.

Little comment is needed as to the length of postoperative hospitalization revealed in Table 4. The single patient not hospitalized was operated upon in the hospital as an ambulatory patient under local anesthesia for the relief of pain. A very large, thrombosed combined hemorrhoid was excised, leaving for subsequent hospitalization the completion of removal of her full rosette. It is interesting that nearly as many patients were discharged on the third postoperative day as remained until the seventh day. In most of the latter, the additional day or two of hospitalization was occasioned by the necessity of making a long trip by automobile to their homes or by the practice of a hospital in which a minority of these patients

TABLE 3.—*Catheterization*

Patients catheterized		11
Foley catheter inserted in operating room	2	
Intermittent catheterization	9	
Once only, on operative day	7 *	
To 36 hr.	1	
To 4th day (bedfast hemiplegic)	1	

* Two received morphine sulfate without trial; three on direct order.

TABLE 4.—*Postoperative Day of Discharge*

Day	No.
0 (operative day)	1
3d	5
4th	13
5th	14
6th	8
7th	6
Plus 1 wk	3 *
	—
Total	50

* One for pleurisy on fifth day; one for orthopedic consultation; one after perineorrhaphy, etc.

were cared for of not discharging patients on a Sunday.

Summary

1. Twenty-two per cent of the patients were given morphine or its equivalent, and only on the day of operation. Perhaps half these patients did not require it. In only two patients to whom acetylsalicylic acid and codeine were given initially was relief of pain inadequate and supplement with a stronger drug required.

2. Twenty per cent of the patients required no analgesic drug.

3. Over one-half the patients required only acetylsalicylic acid, 5 or 10 grains (0.3 or 0.6 gm.), codeine, 32 mg., for relief of pain.

4. Intermittent catheterization was required in eight patients (16%) who previously had normal ability to void. This can perhaps be attributed in part to the unnecessary administration of morphine in five instances.

5. Discharge from the hospital occurred on or before the fifth day in 64% of the patients. Approximately as many left on the third day as on the seventh day.

634 North Grand Blvd.

DISCUSSION

DR. W. G. RAINER, Denver: Along with Dr. Bartlett, we, at the Denver Veterans Administration Hospital during the last nine months, have been interested in evaluating pain resulting from hemorrhoidectomy and the methods of alleviating this pain.

We instituted a double-blind study, so that no one knew the type of hemorrhoid operation to be performed until the patient was in the operating room. Postoperatively, the ward personnel were not informed of the type of procedure used. This gave us a comparison of the merits of the submucous-dissection type of procedure (as described by Parks) and the classic excision type of operation. The amount of postoperative pain was objectively evaluated by the amount of medication required for pain control.

Slide 1 shows the distribution of the 70 cases evaluated thus far, and they are approximately evenly divided between the two series.

Slide 2 shows the distribution into three arbitrary groups, requiring minimal, moderate, and excessive amounts of analgesics and narcotics postoperatively. As can be seen, the majority of the submucous cases required minimal to moderate amounts of medication, whereas the majority of the excision cases required moderate to excessive amounts of drugs for pain relief. This suggests that less discomfort is experienced after anatomic dissection of the hemorrhoidal mass, leaving an intact covering of mucosa.

Anoscopy at time of discharge and two weeks after operation showed the healing to be of comparable degrees in the two groups.

DR. ROBERT J. TENNER, Minneapolis: I think Dr. Bartlett's technique is wonderful; but I can't believe that it prevents patients from having postoperative pain. They will have it regardless. Don't try to tell your patients they won't have pain. Be honest with them, and tell them that this is going to be a really big operation, that they are going to have a lot of pain, and that you will do everything you can for them, with hypodermic medication and sedatives, and so on. Whether a patient is catheterized once, twice, or three times makes not too much difference; in my practice I have seen very few urinary complications.

Having trained in general surgery at the Mayo Clinic and now limiting my practice to proctology, I may say that the two important factors in hemorrhoidectomy are the completeness of the surgical excision and the postoperative care. I do not think that any special technique of resecting the varicosities or the hemorrhoids is very important, but it is necessary to get them all out. The next most important thing is the follow-up of the patient. That is what we as proctologists emphasize most. We often see patients who have been treated surgically but who come to us for strictures and other complications, due invariably to inadequate postoperative care.

If you will follow up these patients and give them an adequate digital examination once a week, and watch them, you will end up with a well-healed anal area. If there is a little band, or adhesion narrowing the anus, this can be snipped with scissors. It won't hurt the patient. One should follow up hemorrhoidectomy patients, and they will be the most grateful and satisfied patients you have in your practice.

DR. GUY V. PONTIUS, Chicago: Sometimes I think hemorrhoidectomy is one of the most important operations we do. We do appendectomies, and our patients soon forget us because their pain does not last long and they soon become comfortable and are well.

However, the patient who has been uncomfortable for months or years with his posterior is a very grateful patient when he is made comfortable. He is willing to stand a reasonable amount of discomfort in order to secure comfort.

I suppose it doesn't make a great deal of difference how one does a hemorrhoidectomy. This problem of submucous dissection has been in the literature for a long time. It seems to come in epidemics. What one must remember, I think, is that hemorrhoidal disease is probably essentially inflammatory, and therefore the more of the perianal structures that can be removed, with a good functioning result, the better the curative results will be for a long time.

I should like to emphasize further Dr. Bartlett's suggestion of sphincter fatigue. I think it is very important, but that does not mean sphincter divulsion, which is traumatic, and one of the causes of postoperative discomfort.

DR. WILLARD BARTLETT, St. Louis: I regret that the limitations of time and space preclude a detailed comment on the sphincter mechanism. Objection may be made that the sphincters should not be said to contract against the speculum, since they would be already paralyzed by caudal or spinal analgesia and would therefore be incapable of work. This objection does not take into account the following points, which are, variously, of accepted physiological doctrine or common clinical observation.

Anesthetic solutions more readily penetrate sensory than motor nerves and nerve roots; hence there is frequently freedom from pain without paralysis of skeletal muscle, such as the external sphincter. In patients thus anesthetized, varying degrees of remaining tonus of the sphincters are seen, but I doubt that the distinction can always be made with certainty as to whether the residual tonus is that of the internal or of the external sphincter. It is assumed that the external sphincter, itself, responds to stretching by contraction, as does other nonstriated muscle.

These are the reasons for my adherence to the view that sphincter fatigue is a state induced in some degree by muscular contraction. It is not regularly reproducible in less than 10 minutes by the method advocated.

Eosinophilic Granuloma of the Ileum

ELMER W. KONEMAN, M.D.; KENNETH C. SAWYER, M.D., and ALEXIS E. LUBCHENCO, M.D., Denver

Interest in eosinophilic infiltrations of the gastrointestinal tract dates back to 1937, when Kaijser [1] first reported three cases. However, it was not until 1949 that Vanek [2] reported six cases occurring in the stomach and established this condition as a clinical-pathological entity. He originally described the lesion as consisting of connective tissue composed of mesenchymal elements (fibroblasts and loosely arranged collagenous fibers), infiltration with eosinophils and lymphocytes, and proliferation of arterioles and lymph capillaries. For lack of a better name, he called this lesion "gastric submucosal granuloma with eosinophilic infiltration," to be distinguished as a separate entity from the eosinophilic granuloma of bone, in which the basal cells are reticulum cells and histiocytes, rather than fibroblasts, and the eosinophilic infiltration is focal, rather than diffuse, as in the lesions described by him. Since that time numerous similar gastrointestinal-tract lesions have been observed and reported by many authors, and a variety of names have been applied to them: eosinophilic granuloma by Booher and Grant,[3] hemangiopericytoma by Stout,[4] hemangioendothelioma by Sawyer and Lubchenco,[5] inflammatory fibroid polyps by Helwig and Ranier,[6] typical schwannoma by Lortat-Jacob and Moricheau-Beauchant,[7] neurofibroma by Feyrter,[8] and fibroma by Konjetzny.[9] The name used by most recent authors on the subject, "eosinophilic granuloma," will be used in this paper to designate the lesions originally described by Vanek.[2]

Eosinophilic granulomas have been described as occurring in all parts of the gastrointestinal tract. Brunner [10] reported cases in the mouth, pharynx, and nasal passages; and Steger and Noto [11] reported a case in the rectum. In by far the largest number of cases reported the lesion has been in the stomach, occurring either singly or as a diffuse process involving the pylorus and proximal part of the duodenum. In 1950 Polayes and Krieger [12] first described the condition in the jejunum, and in 1954 the first case in the ileum was reported by Virshup and Mandelberg.[13] Since this latter publication only a few cases in the small intestine have been reported, and review of the literature reveals only two other cases [14,15] with the primary site in the ileum.

As discussed in a recent paper by Ferrier and Davis,[16] eosinophilic granuloma appears to take two forms. The more commonly reported form occurs as a diffuse infiltration of the intestinal wall, which results in a tube-like thickening with narrowing of the lumen, resembling macroscopically the condition found in regional ileitis. In this type, adhesions to the surrounding tissues are frequently present, although fistula formation has not been reported. In nearly all reported instances of this diffuse type of infiltration, there has been an associated increase in the number of eosinophils in the peripheral blood, with a total sometimes as high as 60%.

Less commonly, the condition takes the form of a localized granuloma. It usually occurs as a polypoid, tumor-like mass, and most of these cases have been reported as involving the pyloric region of the stomach. Histologically, the lesion is usually in the submucosa and is formed mainly by granulation tissue with intense eosinophilic infiltration. Subsequently, the granulomatous process may extend through all the layers of the intestine, producing necrosis of the

Submitted for publication Dec. 11, 1958.

From the Surgery and Pathology Services, Presbyterian Hospital.

mucosa and stiffness of the intestinal wall. Eosinophilia in the peripheral blood is not a feature when the lesion is a localized granuloma.

Symptoms vary, depending upon the site of involvement. Pain is a prominent feature, especially in those lesions occurring in the stomach, which may be mistaken for peptic ulcer. There is often a history of episodes of pain recurring over a period of years. Nausea and vomiting are common, especially if there is any obstruction. Intermittent intestinal obstruction suggests a ball-like action of the tumor, or in the diffuse form of the disease it may be due to a disturbance of peristalsis resulting from infiltration and thickening of the wall of the intestine, or to a cicatricial contracture. If obstruction occurs in the pylorus, it may simulate the radiological picture of pyloric stenosis. Many patients are constipated, although diarrhea may occur if there is mucosal ulceration. Although occult blood and melena have been reported, these are not common presenting complaints.

The etiology of eosinophilic granuloma remains obscure. There is some controversy concerning the nature of the process, although most authors are agreed that the condition is inflammatory in nature, taking the form of a nonspecific granuloma with a diffuse accumulation of eosinophils in the granulation tissue. However, in many cases there has been abnormal proliferation of the stromal elements, leading to diagnoses such as hemangiopericytoma, hemangioendothelioma, fibroma, neurolemmoma, and neurofibroma, as discussed above. Two of us K. C. S. and A. E. L.[5] have previously reported a case of hemangioendothelioma, and the latter (A. E. L.) still believes this case to be distinct from the usual eosinophilic granulomas reported, and definitely a neoplastic process. However, Helwig[6] considers this interpretation unwarranted, and there are numerous cases among the 10 reported by him which show a histologic picture with concentric layering of the fibrillar connective tissue around blood vessels, simulating hemangioendothelioma and hemangiopericytoma. He considers this as evidence of maturation in a healing inflammatory process. Helwig supplies the additional evidence that the lesion is inflammatory by observing that the bundles of hypertrophied muscularis mucosa are split and frayed, rather than pushed aside, as they would be if the process were neoplastic. The subject remains open for discussion.

The role of allergy was discussed by Kaijser[1] in his first reported case, that of a patient who had had an allergy to onions since his youth. In most of the subsequent cases there has been no associated allergic disease, and allergy was absent in Vanek's[2] six reported cases. It would appear that the intense eosinophilic infiltration of the granuloma in this disease represents a focal atopic reaction of the host tissue to an irritant, although a specific irritant and proof of the sensitization of the host to the irritant remain to be demonstrated.

As was stated above, the diffuse form of eosinophilic granuloma may resemble, macroscopically, regional ileitis, which is another nonspecific intestinal granulomatous disease. As Warren and Sommers[17] described the pathogenesis of regional enteritis, the chronic irritation of the intestine, with blockage of the submucosal lymphatics, results in lymphedema of the submucosa, which progresses to granuloma; this explanation may apply equally well to eosinophilic granuloma. However, it would not appear to explain the focal form of the disease, where, in most cases, the adjacent intestine is normal.

Helwig[6] made the interesting observation that the gross shape of inflammatory fibroid polyp of the stomach (synonymous with our term "eosinophilic granuloma") is similar to that of granuloma pyogenicum occurring on the skin and squamous mucous membrane. He believes it is conceivable that the inflammatory fibroid polyp of the stomach is the glandular-membrane counterpart of the lesion and that the dissimilarity of morphologic detail is due to basic differences in the stroma of the two sites.

Kerr [18] stated that granuloma pyogenicum arises as a result of minor trauma, with a localized overgrowth of granulation tissue and an exaggerated endothelial proliferation. Mock [19] describes nonspecific infective granuloma of the gastrointestinal tract and postulates a continuing slow necrosing process, with corresponding increase in the reparative process. There is no doubt that once the inflammatory fibroid polyp is formed it is enlarged by mechanical action of the food content of the intestine.

In the differential diagnosis of eosinophilic granuloma, various specific granulomas of the gastrointestinal tract due to syphilitic, tuberculous, and parasitic infections must be considered. Skin tests, serologic examination, and examination of stools for specific organisms should be carried out. Special histologic stains of the processed material may be of aid in demonstrating a specific causative organism. If the granuloma is lipid or due to foreign body, this can usually be determined from the history.

Numerous papers have been written concerning the radiological manifestation of eosinophilic granuloma. However, the diagnosis is usually made at operation by frozen section, or by subsequent permanent sections. Owing to the various forms taken by this disease and its frequent similarity, radiologically, to carcinoma, we feel that laparotomy and biopsy of all polypoid lesions of the intestine should be carried out.

There is some controversy regarding the management of the diffuse type of eosinophilic granuloma. Orr, Miller, and Russell [20] reported a case of eosinophilic infiltration of the gastrointestinal tract which showed a dramatic spontaneous remission, after the patient had undergone four laparotomies in the course of four years. They suggest that the treatment of eosinophilic infiltration should be conservative except in the presence of obstruction. They also report remission of the tumor following corticotropin therapy. In their recent paper, Ferrier and Davis [16] suggest a trial of corticotropin during exacerbations of symptoms in suspected cases of eosinophilic infiltration of the gastrointestinal tract. They resort to laparotomy only to confirm the diagnosis or to relieve complications. At laparotomy, if frozen section confirms the diagnosis of eosinophilic infiltration of the intestine, the abdomen should be closed and conservative therapy instituted, unless an obstruction exists, in which instance proper surgical resection should be carried out. Orr, Miller, and Russell [20] do not believe there is any justification for extensive resection, since the condition is not progressive, as in Crohn's disease (regional ileitis). If vulnerable structures are involved, the authors feel a short circuit would be the most reasonable procedure.

Report of a Case

A 45-year-old white man was admitted to the hospital in August, 1958, with a history of intermittent, cramping abdominal pain of one month's duration. Six years previously he had experienced epigastric pain suggestive of duodenal ulcer. This was alleviated by a specific medical regimen. The present pain started in the suprapubic area and radiated throughout the entire abdomen and lower back, being relieved after one or two hours' rest. Three days prior to the patient's admission to the hospital, the pain occurred more frequently and more severely and was accompanied by episodes of vomiting, no gas or stool being passed by rectum. There had been no melena, and no hematemesis, fever, chills or jaundice occurred. This patient had enjoyed good health, with a questionable history of undulant fever as a child. There was no history of past or present allergic complaints.

The patient was a well-developed, well-nourished white man. The blood pressure was 130/80, the pulse 88, and the temperature 99 F. The abdomen was distended and diffusely tender without rebound; the bowel sounds were hypoactive and high-pitched. None of the abdominal organs or other masses were externally palpable. The remaining physical examination was not remarkable. A plain roentgenogram of the abdomen revealed multiple distended loops of small intestine with fluid levels. The laboratory data showed leukocytes, 6,200 with 40% polymorphonuclear cells, 30% stab cells, 26% lymphocytes, 3% monocytes, and only 1% eosinophils. The urinalysis revealed specific gravity of 1.080, with a positive acetone reaction and negative sediment. The serum amylase value was 160 units

Fig. 1.—Gross specimen of the opened ileum, showing polypoid eosinophilic granuloma.

(normal, 60-160 units), and the serum lipase 0.22 Todd unit.

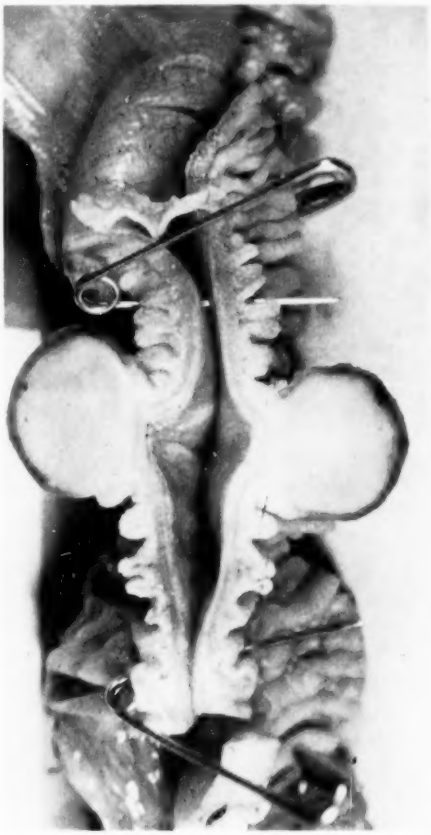
After a short trial of medical therapy, a laparotomy was performed. When the abdomen was opened, large distended loops of small intestine were seen. There was an intussusception of the ileum, and a well-defined polypoid tumor was palpated at the head of the intussusception. A portion of this tumor was excised for frozen-section study, which showed a benign tumor with extensive inflammation. Glands were found in the mesentery, and frozen-section study of one of these revealed reactive hyperplasia. About 2 ft. (60 cm.) of ileum, including the tumor, was resected, and gastrointestinal continuity was reestablished by a closed, end-to-end anastomosis, carried out over a Rankin clamp.

Pathologic Observations.—The fixed resected portion of the ileum measured 28 cm. in length (Fig. 1). A small amount of mesentery was attached. The serosal surface was intact and showed injection of the superficial vessels. The wall was not thickened. The mucosa was interrupted in numerous areas in the proximal portion by linear ulcerations extending into the submucosa. In the central portion of the specimen was a granular, red-brown polypoid structure, 2.5 cm. in diameter, which protruded 2 cm. into the lumen, sub-totally occluding it. Cross section revealed a homogenous, firm, glistening, gray-white material surmounted by a thin zone of granular red-brown tissue, as seen on the surface (Fig. 2). This lesion extended to the external muscle layer. A small node was found in the adjoining mesentery.

On microscopic examination the mucosa was found to be ulcerated and replaced by an overlying pyogenic membrane superimposed on a granulation type of tissue (Fig. 3). This tissue was composed of proliferating capillaries in a loosely arranged stroma, which consisted of a fine fibrillary structure incorporating a pale, granular, indistinct type of material. Included were uniform mature nuclei that were spindle to oval-shaped, generally presenting one distinct small nucleolus. The cytoplasm was pale and indistinct and in some instances was observed to form the fine fibrillary structures. There was also a coarser, light red, wavy reticular collagen structure. This, in turn, was heavily and diffusely infiltrated with eosinophilic granulocytes and scattered lymphocytes and plasma cells. Fragmentation of the muscularis mucosa and internal muscle layers was noted, and the subserosa was thickened and reflected an underlying inflammatory reaction.

Sections were also made through the ulcerated areas in the proximal portion of the specimen. Microscopic examination revealed interruptions in the mucosa extending into the submucosa, and infiltration of the adjacent lamina propria with both

Fig. 2.—Cut surface of the eosinophilic granuloma, showing ulceration of the mucosa with replacement by a pyogenic membrane.



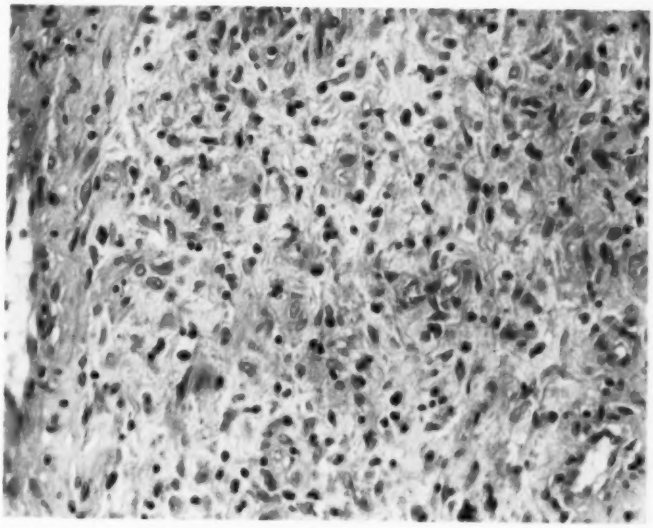


Fig. 3. — Microscopic section, showing granulation tissue, with proliferating capillaries, fibroblasts, and a diffuse infiltration with eosinophilic granulocytes.

acute and chronic inflammatory cells, including eosinophils and plasma cells. Special stains of these sections revealed no evidence of pyogenic, mycotic, or parasitic organisms.

This patient's postoperative course was uneventful, and he was discharged from the hospital on the 11th day following surgery.

1839 High St. (Dr. Sawyer)

REFERENCES

1. Kaijser, R.: Über Hämangiome des Tractus gastrointestinalis, Arch. klin. Chir. 187:351-388, 1937.

2. Vanek, J.: Gastric Submucosal Granuloma with Eosinophilic Infiltration, Am. J. Path. 25:397-411, 1949.

3. Booher, R. J., and Grant, R. N.: Eosinophilic Granuloma of the Stomach and Small Intestine, Surgery 30:388-397, 1951.

4. Stout, A. P.: Hemangiopericytoma: Study of 25 New Cases, Cancer 2:1027-1054, 1949.

5. Sawyer, K. C., and Lubchenco, A. E.: Hemangioendothelioma of the Stomach, Surgery 30:383-387, 1951.

6. Helwig, E. B., and Ranier, A.: Inflammatory Fibroid Polyps of the Stomach, Surg. Gynec. & Obst. 96:355-367, 1953.

7. Lortat-Jacob, J. L., and Moricheau-Beauchant, J.: Schwannome typique des l'estomac, Arch. mal. app. digest. 40:122-124, 1951.

8. Feyrter, F.: Über die vasculäre Neurofibromatose, nach Untersuchungen am menschlichen Magen-Darmschlauch, Arch. path. Anat. 317:221-265, 1949.

9. Konjetzny, G. E.: Über Magenfibrome, Beitr. klin. Chir. 119:53-61, 1920.

10. Brunner, H.: Eosinophilic Granuloma of Mouth, Pharynx, and Nasal Passages, Oral Surg. 4:223-640, 1951.

11. Steger, C., and Noto, L.: Granuloma del retto do tipo eosinofilo, Acta chir. patav. 9:339-344, 1953.

12. Polayes, S. H., and Krieger, J. L.: Eosinophilic Granuloma of the Jejunum: A Hitherto Undescribed Lesion of the Intestines, J. A. M. A. 143:549-551, 1950.

13. Virshup, M., and Mandelberg, A.: Eosinophilic Granuloma of the Gastro-Intestinal Tract: Report of a Case Involving the Ileum, Ann. Surg. 139:236-240, 1954.

14. Unnewehr, F., and Ohrt, H.: Eosinophiles Granulom des Dünndarms als Ursache für einen Ileus, Zentralbl. Chir. 79:91-93, 1954.

15. Urban, A., and Lenczyk, M.: So-Called Eosinophilic Granuloma of the Ileum, Pat. polska 7:307-311, 1956.

16. Ferrier, T., and Davis, N.: Eosinophilic Infiltration of the Stomach and Small Intestine, M. J. Australia 1:789-791, 1957.

17. Warren, S., and Sommers, S. C.: Cicatrizing Enteritis (Regional Ileitis) as a Pathologic Entity, Am. J. Path. 24:475-501, 1948.

18. Kerr, D. A.: Granuloma Pyogenicum, Oral Surg. 4:158-176, 1951.

19. Mock, H. E.: Infective Granuloma: Non-Specific Chronic Tumor-like Productive Inflammations of the Gastro-Intestinal Tract, Surg. Gynec. & Obst. 52:672-689, 1931.

20. Orr, I. M.; Miller, A. A., and Russell, J. Y. W.: Eosinophilic Infiltration of the Stomach and Bowel, Postgrad. M. J. 30:485-493, 1954.

Hypertrophy of Ileocecal Valve

Plastic Repair

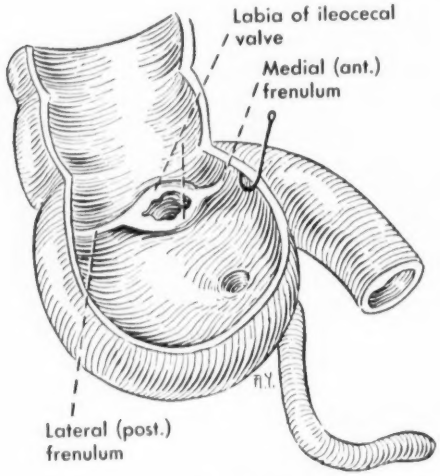
MOHAMMED H. SALEM, M.B., B.Ch., and HARRY H. McGEE, M.D., Durham, N. C.

Hypertrophy of the ileocecal valve, lipomatosis of the ileocecal region, and ileocecal syndrome are synonymous terms. On reviewing the literature, one is impressed with the comparative infrequency of clinical lipomatosis of the ileocecal valve, although an appreciable number of cases have been noted post mortem.[1,2]

Comfort [1] reported an incidence of submucous lipomas of the gastrointestinal tract found at autopsy as varying from 0.06% to 0.6%. Seabrook's [3] review of the literature revealed 12 cases, and he added 3 cases of his own. The purpose of the present paper is to discuss the anatomy, physiology, and symptomatology of the so-called ileocecal syndrome. A new technique for plastic repair of this hypertrophied valve is also presented.

Submitted for publication Nov. 10, 1958.

From the Department of Surgery and Radiology, Duke Medical Center.



The ileocecal valve.

Fig. 1.—Reproduced from Hollinshead's Anatomy for Surgeons, Vol 2, by permission of the publisher, Paul B. Hoeber, Inc. (Book Department of Harper & Brothers).

Anatomy

Anatomically,[4,5] the ileocecal valve (Fig. 1) presents essentially a protrusion of the mucosa, submucosa, and circular muscles of the ileum into the lumen of the colon. It is composed of two folds, the lips, or labia, bounding the slit-like opening which connects the small with the large intestine. This slit is said to lie on the posteromedial aspect of the junction of the cecum and the ascending colon and runs transversely to the long axis of the large intestine. The two labia which constitute the valve vary in size, the upper one being the larger as a rule. Buirge [6] found the superior labium to project into the lumen of the colon from 0.4 to 2.5 cm., the average distance for 443 specimens being 1.5 cm. On their adjacent aspects, the lips are formed of muscle and mucosa from the ileum, and on the side away from the opening they are formed of muscle and mucosa from the colon. At the junction of the upper and lower lips, the elevation of the wall is carried part way around the inner surface, forming the two frenula, a medial (or left or anterior) and a lateral (or right or posterior). This medial frenum is absent in 22% of cases, the lateral one in 2%, and both in 2%. In the fresh normal specimen, the margins of the opening are elevated very little and feel no different from the rest of the cecal wall.

Physiology of the Valve

The physiology of the ileocecal valve [4] is not completely understood. It is stated that

both the circular and the longitudinal muscle coats of the ileum and colon enter the labia and produce a sphincter-like action. Buirge[8] observed directly this sphincter-like action in a fistulized cecum and reported that, while there was no tonic contraction typical of a true sphincter at the ileocecal junction, stimulation of the mucosa and attempts to stretch the orifice of the valve produced marked contraction. This sphincter was, however, inhibited by distention of the colon, contrary to what one might expect if it functioned to prevent reflux. Hunter[9] described the inferior lip as acting passively to prevent regurgitation from the colon into the ileum, this action depending upon the position of the terminal part of the ileum and filling of the cecum; but the frequently deficient condition of the lip, as described by Buirge, would indicate that it, at least alone, is not an important factor in preventing regurgitation.

Apparently a combination of muscular contraction and passive valvular action is completely efficient in closing the aperture. According to Fleischner and Bernstein,[10] reflux from the colon into the ileum occurs in about 90% of persons if the colon is distended and the cecum palpated.

Clinical Features

Unencapsulated accumulation of fat involving the ileocecal valve in sufficient quantities to produce symptoms is no longer a pathologic curiosity. In fact, submucosal lipoma is second in frequency of the benign tumors of the colon, the cecum being the commonest site in the large bowel. Whether or not lipomatous hypertrophy of the ileocecal valve deserves to be looked upon as a pathologic change needing surgical correction is likely to be the subject of some differences of opinion.

According to Rigler and Lasser,[12] the condition is characterized by a common symptom complex, mainly abdominal pain, vague or colicky, distention, and tenderness on palpation over the cecal area. This may be accompanied with nausea and vomiting. Change in bowel habits, either constipation or watery diarrhea,[13] is reported. Should the mucosa ulcerate, blood will be found in the stools, either bright red or melenic, and eventually the patient becomes anemic. Seabrook[3] reported three cases of exanguinating hemorrhages; all were treated with resection and anastomosis.

The presenting symptoms suggest that a neoplasm may be present. The duration of symptoms and absence of a palpable mass, however, decrease the likelihood of this possibility. The radiologist may find a distinct shadow in the cecum which also suggests a tumor.

Distinction preoperatively between this lesion and a pedunculated tumor, or even carcinoma, cannot be determined with any certainty. However, the extremely sharply defined mass which lies in the cecum in the region of the valve makes a fatty ileocecal valve a most likely diagnosis, as in the following case.

Report of Case Treated with Plastic Repair of Valve

A 65-year-old white married woman was first seen at Duke Hospital in November, 1957, with the chief complaint of pain in the right side for approximately one and one-half years. She had apparently been in good health until she noted the onset of the pain in the right lower abdominal quadrant, which was recurrent in nature. She also had an occasional episode of colicky epigastric pain, which was associated with nausea but no vomiting. There was no history of other gastrointestinal symptoms, no melena or diarrhea. She had lost an unknown amount of weight, and more laxatives were required. The past history was not remarkable except for a history of appendectomy some years ago, with a slight bulge in the site of the old appendectomy scar. General physical examination was not remarkable, except for obesity. A small hernia was felt in the right lower quadrant, but no tenderness or mass was felt. Proctoscopic examination was normal. Results of laboratory studies, including liver function tests, were within normal limits. Urine tested for serotonin (5-HIAA) was negative. A barium enema showed a filling defect 3-4 cm. in diameter at the junction of the cecum and the ascending colon on the medial side, which was well demonstrated on pressure spot films (Fig. 2).

In view of the persistent defect in the ileocecal region, surgical exploration was carried out through

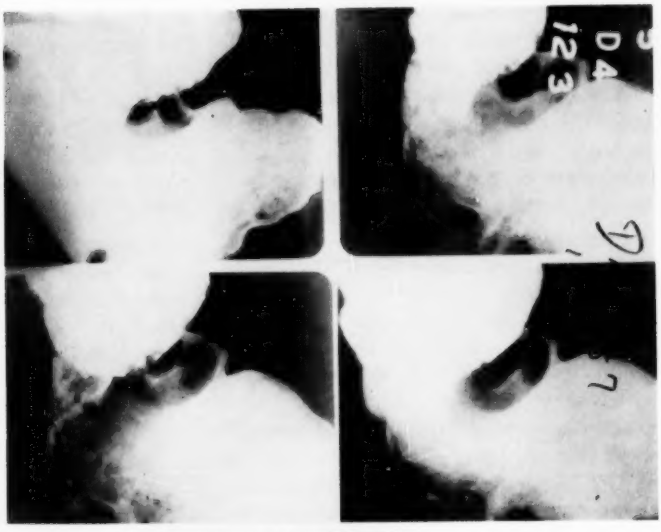


Figure 2

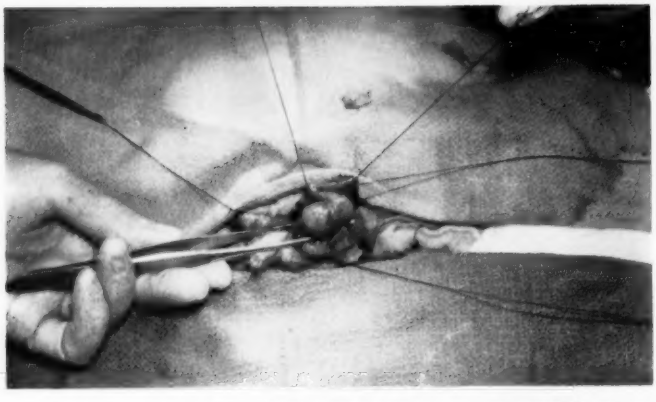


Figure 3

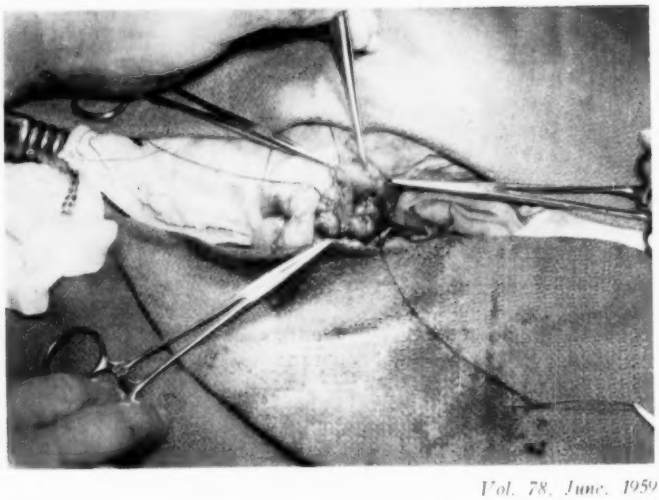


Figure 4

Figure 5

the old McBurney scar, which was excised. Marked adhesions between the abdominal wall, ileum, and cecum were divided. The incisional hernia was dissected free from its attachment to the cecum. The right colon was mobilized for better exposure, and careful inspection revealed no evidence of serosal involvement. A rather soft abnormal structure could be felt intraluminally at the junction of the terminal ileum with the cecum. The cecum was opened through the anterior taenia coli, and no gross mucosal involvement was noted in the distal cecum or the ascending colon. However, on palpation, the junction of the terminal ileum with the cecum, the ileocecal valve showed a peculiar fatty infiltration, which was firm in areas. The valve itself admitted one finger into the terminal ileum. The lip of the valve measured between 1.5 and 2.5 cm. in diameter (Fig. 3). A biopsy specimen from the hypertrophied valve was taken, and frozen section revealed no abnormal tissue. A plastic repair was done by partial excision of the valve in three areas, each for a distance of about 1.5 cm., thus leaving normal mucosa intact between the resected areas, which were sutured (Fig. 4).

Figure 6

It was felt that the subsequent scarring would prevent prolapse of the valve into the cecum and at the same time would not cause any stricture of the valve. The cecum was closed and the abdominal wall incision repaired. Her postoperative course was uneventful. The patient has been followed for six months, with complete relief of the abdominal symptoms. A barium enema four months after surgery (Fig. 5) showed improvement in the appearance of the cecum which outline was regular. There was also some reflux of barium into the terminal ileum.

Pathology (Fig. 6.)—The specimen (three pieces of tissue from hypertrophied ileocecal valve) measured from 25×8×4 to 15×7×4 mm. in greatest dimension. There was an abundant amount of fat composing most of the tissue. Microscopic examination revealed colonic mucosa, lamina propria, and muscularis mucosa. There was normal-appearing fat subjacent to the muscularis mucosa. There was no ulceration of the mucosa. In the lamina propria there were a few chronic inflammatory cells and numerous pigment-laden macrophages.

Comment

Smith,[19] in a discussion of a paper by Edwards and Zangara, considered the relationship of the clinical entity of hypertrophied ileocecal valve and faulty fat metabolism and Whipple's disease. The last condition is characterized by deposits of encapsulated fat in which the mucosa of the jejunum and ileum is replaced by lipid tissue. The problem arises as to whether or not this represents a separate pathologic condition or a hypertrophied ileocecal valve with more than the usual amount of submucosal fat. Its location at an anatomic narrowing and its appearance on barium enema studies makes surgical intervention inevitable in ruling out neoplasm. Obviously, preoperative distinction between this lesion and a pedunculated tumor, or even carcinoma, cannot be made with certainty. Scarborough[22] stated that the differential diagnosis is sometimes difficult. He reported two cases, one of lymphosarcoma of the ileum intussuscepted into the ileocecal valve, and the other of annular adenocarcinoma of the ileocecal valve. Both cases were mistakenly diagnosed preoperatively as lipomatosis of the ileocecal valve.

Some of the other causes of radiological filling defect at the ileocecal valve are as follows:

I. Unusually conspicuous ileocecal valve of normal size
   A. Pericecal and retrocecal adhesion
   B. Retrocecal mass
   C. Posterior implantation of ileum on cecum
   D. Common ileocecal wall
II. Unusually large ileocecal valve
   A. Adenoma, polyp, or lipoma of lips
   B. Hypertrophy
   C. Fatty infiltration
   D. Tumor of the valve lips, carcinoid, or carcinoma
III. Invagination or prolapse of soft tissue through the valve
   A. Normal ileal mucosa
   B. Abnormal ileal mucosa
IV. Combination of the above

There is some resemblance of hypertrophied ileocecal valve to prolapse of gastric mucosa through the pylorus. However, the principles of treatment are different in these two conditions. There are several reports[3,11,13] in which lipomatosis of the ileocecal valve was treated with side-resection. Resection of an ileocecal valve area simply because it is large or permits prolapse of the ileal mucosa would not appear to be justified. Nevertheless, should surgery be required, biopsy of the valve is essential to rule out submucosal pathology. The plastic repair noted above should be satisfactory as the anatomy is preserved and the physiology of the valve remains intact. Moore,[21] in discussion of a paper by Seabrook and associates,[3] indicated a similar opinion. In his case, he performed circumcision of the ileocecal valve, incising down one side and following the circumcision with a lock stitch of absorbable surgical (gut) suture. His patient had remained well.

Summary

Hypertrophy of the ileocecal valve, i. e., infiltration of fat, may result in clinical manifestations of various types, mainly pain. Roentgenologic studies will suggest the presence of this pathology, but operation will be required, as the possibility of malignancy cannot be excluded. Partial

excision and plastic repair produced a satisfactory result in one patient.

Department of Surgery, Duke University School of Medicine.

REFERENCES

1. Comfort, M. W.: Submucous Lipomata of the Gastrointestinal Tract: Report of 28 Cases, Surg. Gynec. & Obst. 52:101-118, 1931.

2. Wiener, M. F., and Polayes, S. H.: Benign Tumors of the Ileocecal Region, with a Survey of the Literature, Am. J. Surg. 40:538-544, 1938.

3. Seabrook, D. B.; Stevens, R.; Scholl, V., and Nohlgren, J.: Lipomatosis of the Ileocecal Region, Am. J. Surg. 92:214-221, 1956.

4. Hollinshead, W. H.: Anatomy for Surgeons, Vol. 2: The Thorax, Abdomen and Pelvis, New York, Paul B. Hoeber, Inc. (medical book department of Harper & Brothers), 1956.

5. Anson, B. J., and Maddock, W. G.: Callander's Surgical Anatomy, Ed. 3, Philadelphia, W. B. Saunders Company, 1953.

6. Buirge, R. E.: Gross Variation in the Ileocecal Valve: A Study of the Factors Underlying Incompetency, Anat. Rec. 86:373-385, 1943.

7. Golden, R.: Enlargement of the Ileocolic Valve, Am. J. Roentgenol. 50:19-23, 1943.

8. Buirge, R. E.: Experimental Observations on the Human Ileocecal Valve, Surgery 16:356-369, 1944.

9. Hunter, R. H.: The Ileo-Caecal Junction, J. Anat. 68:264-269, 1934.

10. Fleischner, F. G., and Bernstein, C.: Roentgen-anatomical Studies of the Normal Ileocecal Valve, Radiology 54:43-58, 1950.

11. Edwards, M., and Zangara, H.: Lipomatous Hypertrophy of the Ileocecal Valve, Am. J. Surg. 82:533-537, 1951.

12. Rigler, L. G., and Lasser, E.: Prolapse of the Lower Lip of the Ileocecal Valve into the Terminal Ileum, Am. J. Roentgenol. 65:878-881, 1951.

13. Linton, R. R., and Castleman, B.: Redundant Lipomatous Ileocecal Valve, Case Records of Massachusetts General Hospital, New England J. Med. 248:382-385, 1953.

14. Hinkel, C. L.: Roentgenological Examination and Evaluation of the Ileocecal Valve, Am. J. Roentgenol. 68:171-182, 1952.

15. Sawyer, K. C.; Lubchenco, A. E., and Stewart, M. J.: Lipoma of Ileum with Intussusception and Carcinoma of Cecum, A. M. A. Arch. Surg. 64:128-130, 1952.

16. Bigelow, R. R., and Anlyan, A. J.: Submucous Lipomas of the Colon, Arch. Surg. 59: 114-128, 1949.

17. Ellis, J. T., and Windham, S. W.: Recurrent Abdominal Pains Due to Lipoma of Ileum, A. M. A. Arch. Surg. 63:859-860, 1951.

18. Strombeck, J. P., cited by Golden.[7]

19. Smith, D. W., in discussion on Edwards and Zangara.[11]

20. Mallory, T. B.; Castleman, B., and Parris, E. E.: Submucous Lipoma of the Ileocecal Valve, New England J. Med. 229:948:950, 1943.

21. Moore, A. E., in discussion on Seabrook and others.[3]

22. Scarborough, R. A., in discussion on Seabrook and others.[3]

23. Pack, G. T., and Booher, R. J.: Intussuscepting Submucous Lipoma of Right Colon, S. Clin. North America 27:361-372, 1947.

24. Mayo, C. W., and Greiss, D. F.: Submucous Lipoma of the Colon, Surg. Gynec. & Obst. 88:309-316, 1949.

25. Colcock, B. P., and Weidman, J. G.: Intussusception Due to Submucous Lipoma of the Colon: Case Report, Lahey Clin. Bull. 8:40-44, 1952.

26. Warren, K. W., and Brandenburg, F. H.: Lipomas of the Gastrointestinal Tract, S. Clin. North America 31:743-752, 1951.

Meckel's Diverticulum

A Case Diagnosed by X-Ray

CLAUDE W. BARRICK, M.D., and KENNETH E. FRY, M.D., Philadelphia

Meckel's diverticulum is one of the most frequently discussed, one of the least specifically diagnosed, and one the most surgically gratifying of all the abdominal lesions. Its incidence is low enough to remove it from the list of common causes of intestinal bleeding or bowel obstruction, except in children and adolescents. Gross [1] described 149 patients with Meckel's diverticulum upon whom surgery was performed. Nearly half were in the first two years of life, with a male-female ratio of 3:1. In this group the complications which arose did so early in life. His oldest patient was 14 years of age. Inversion with intussusception was common. His experience with roentgen diagnosis was so disappointing (only two showed a questionable lesion) that this procedure was completely abandoned. Massive hemorrhage was the chief complication occurring in 50 children. In this series the mucosa lining the pouch was gastric, ileal, colonic, pancreatic, duodenal, or a combination of two or more of these tissues. Gastric and ileal, ileal and gastric, and pancreatic and ileal were the commonest, in that order of frequency. The common complications were ulcer and hemorrhage, pain, intussusception, inflammation, umbilical fistula, cyst formation, and obstruction, in order of frequency.

Report of Case

A 25-year-old white male medical student was admitted to Jefferson Hospital on June 15, 1958, with a history of abdominal cramps, diarrhea, vomiting, and rectal bleeding. Physical examination revealed blood pressure 95/60, pulse 80 reclining, 100 sitting. Abdominal examination was normal. Rectal examination revealed dark blood in the stool. The hematocrit was 37%; the hemoglobin concentration, 11.6 gm. %. X-ray examination of the stomach revealed a concentric hiatus hernia. Colon fluoroscopy revealed suspicion of intussuscepting tumor of the ileum (Fig. 1.). A small-bowel examination with fluoroscopy demonstrated the same lesion in less detail (Figs. 2 and 3). Colon fluoroscopy was repeated with intent of demonstrating the ileum under close control. This revealed the lesion in clear detail (Figs. 4 and 5). It was thought to be a benign tumor. At laparotomy the hiatus hernia was confirmed, and a tumor of the small bowel was palpated. After enterostomy a 3 cm. Meckel diverticulum was discovered to be inverted. There was a 6 mm. ulcer crater at its tip. Gastric mucosa was not identified histologically. The patient made an uneventful recovery.

Figure 1

Comment

The x-ray diagnosis in this case was largely due to fortuitous circumstances. Quite by accident, more of the terminal

Submitted for publication Aug. 15, 1958.

From the Departments of Radiology and Surgery, Jefferson Medical College Hospital.

Figure 2

ileum was filled during the original barium enema than was intended. The lesion was seen at the very tail of the barium column in the ileum. The final colon examination, made with the intent of filling the ileum, revealed the lesion in fine detail, and the true diagnosis should have been suspected. Its base was nearly as broad as the tip and was covered with normal-appearing mucosa.

A similar case was discussed at the weekly clinical pathological exercises of the Massachusetts General Hospital.[2] In this instance the roentgen findings were clear-cut in demonstrating the lesion. Its true nature was

Figure 3

not suspected, but the physician discussing the case made the diagnosis. A routine examination of the small bowel failed to show the lesion, again demonstrating the fallibility of small-bowel examinations with oral barium.

A roentgenographic demonstration of the lesion was not accomplished in 100 consecutive cases of Meckel's diverticulum previously reported from this hospital.[3]

Unless the radiologist has enough freedom to examine the small bowel centimeter by centimeter under a fluoroscope, his chances of demonstrating Meckel's diverticulum are very slight. Unfortunately, it is common for radiologists to be unable to spend the time to conduct small-bowel examinations with this much detail and precision. The proof of this hiatus in diagnostic

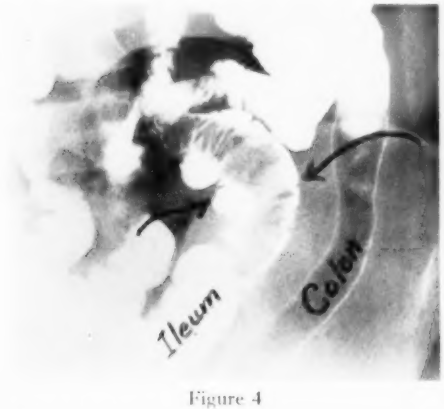


Figure 4

Figure 5

accuracy is the failure of small-bowel examinations to demonstrate Meckel's diverticulum at anywhere near the autopsy frequency of about 2%. If this examination approached the accuracy of, for example, cholocystography, then all small-bowel lesions should be sought for with reasonable assurance that they will be found.

When a Meckel's diverticulum is suspected, clearly demonstrated, and finally surgically proved, the person responsible for the x-ray diagnosis usually cannot escape the feeling that the diagnosis came about through sheer luck or fortuitous circumstances which are not reproducible or predictable.

Lesions of the ileum are more reliably demonstrated by filling retrograde during colon fluoroscopy and examining the individual loops systematically with compression. Oral barium is much less reliable because the contrast medium becomes much less fluid and scattered. The use of different types of intestinal tubes requires time and patience in passing them close to the lesion. Once they are properly placed, they can show the lesion in great detail.

It is argued that the emphasis on detail and precision in the demonstration of small-bowel lesions are unnecessarily time-consuming, when all that is desired is for the surgeon to know whether or not there is good evidence to support the existence of a lesion. However, it is only the most precise roentgen methods which demonstrate the presence or absence of the lesion with certainty. This can be life-saving for critical patients who have been repeatedly x-rayed, with unclear conflicting diagnoses, from more than one institution. Once such a lesion is shown beyond question, then the determination of its true nature becomes an exercise in gross morbid anatomy and statistics. Diagnostic skill depends on past experience, and when the latter has been of the highest precision, the future accuracy will be high. The old saw that one cannot see cells on an x-ray film is still fundamental, but is often used as a comforting defense mechanism for those who refuse to think. It is surprising how one's knowledge of morbid anatomy and medical statistics can lead to high diagnostic accuracy.

Summary

A case of Meckel's diverticulum is presented. It was demonstrated roentgenologically and proved surgically.

Department of Radiology, Jefferson Medical College Hospital.

REFERENCES

1. Gross, R. E.: The Surgery of Infancy and Childhood—Its Principles and Techniques, Philadelphia, W. B. Saunders Company, 1953, p. 211-219.

2. Case #41302: Case Records of the Massachusetts General Hospital, New England J. Med. 253:150-153 (July) 1955.

3. Wagner, F. B., Jr.; Shallow, T. A., and Eger, S. A.: Gastroenterological Aspects of Meckel's Diverticulum: Analytical Review of 100 Cases, Am. J. Gastroenterol. 23:195-204 (March) 1955.

Extensive Aortic-Iliac-Femoral Grafting

Report of Three Cases

W. ANDREW DALE, M.D., Nashville, Tenn.

There are many reports of grafts from the aorta to the femoral vessels in the thighs, and we have used this graft several times where anastomosis to the iliac vessels within the abdomen was impossible or appeared likely to become thrombosed. Unilateral extension of a bifurcation graft down to the popliteal artery has been reported by Crawford, Creech, Cooley, and De Bakey [1]; by Linton and Menendez,[5] the latter reporting healing of a shin ulcer after grafting, and by Laufman, Hohf, Bernhard, and Trippel.[4] The problems connected with graft replacement of the distal aorta and the femoropopliteal system simultaneously prompt this discussion of experience, since further need for such a procedure will undoubtedly occur.

Submitted for publication Sept. 22, 1958.

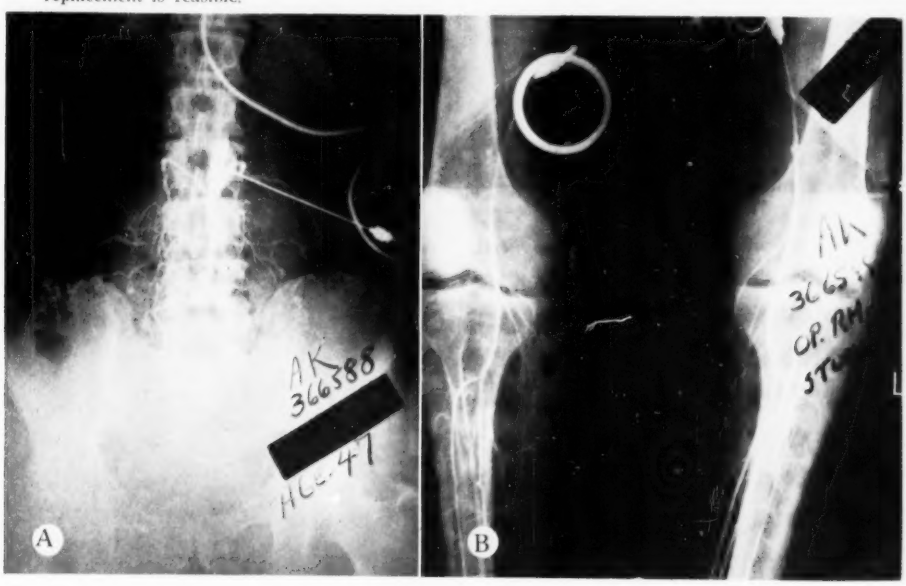
From the Department of Surgery, University of Rochester School of Medicine and Dentistry, Rochester, New York.

Report of Cases

CASE 1.—A 47-year-old white man had been followed for several years elsewhere because of peripheral vascular disease, for which a bilateral lumbar sympathectomy had been performed in 1950, with a diagnosis at that time of thromboangiitis obliterans. His claudication had gradually become worse in both calves, and seven months prior to admission he had developed an ulcer of the dorsal surface of the left foot over the first

Fig. 1 (Case 1).—*A*, aortographic injection of 5 cc. of 50% diatrizoate (Hypaque) outlining a narrowed distal aorta and showing extensive reflux into collaterals. Further injection was contraindicated.

B, simultaneous bilateral operative popliteal arteriograms made by injecting 10 cc. of 50% diatrizoate. The distal "run-off" system on each side is patent, and extensive vascular replacement is feasible.



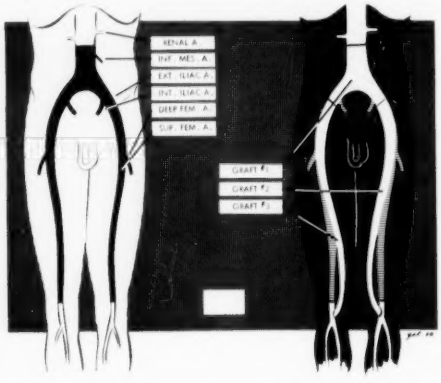
metatarsophalangeal joint, which had failed to heal despite all treatment, including pinch grafts. Pain had progressed to the point of severe night pain, making sleep difficult and causing him to hang his foot over the side of the bed most of the time.

Examination showed that the left foot was edematous about an encrusted, infected ulceration of the dorsal aspect of the first metatarsophalangeal joint. Both feet became cadaveric on elevation. There was no pulse palpable at any point in the lower extremities. The oscillometer showed complete absence of pulsation everywhere in both lower extremities. An aortogram, which had been made on Nov. 15, 1954, was reexamined and found to show scalloping of the distal aorta, with a complete loss of visualization of the left common iliac, external iliac, and superficial femoral arteries but with reconstitution of the popliteal artery on the left. On the right the common iliac artery was present, but the external iliac was not visualized, nor was the superficial femoral artery. However, the popliteal artery did show reconstitution. Because of the lapse of time since the aortogram was taken, a new one was made on July 29, 1957, only 5 cc. of 50% diatrizoate (Hypaque) sodium being injected. Figure 1*A* shows that, while the distal aorta was narrowed, it did fill, although the iliac systems were not demonstrated. No more diatrizoate was administered because it was believed dangerous to place more of this solution into a completely blocked terminal aorta.

Fig. 2 (Case 1).—Homologous arterial grafts sutured together and laid out on the patient prior to anastomosis.

On July 30, operation was performed under general anesthesia. Initially, both proximal popliteal arteries were exposed by incisions over the medial distal thighs. These healed incisions are seen in Figure 4*A*. Simultaneous bilateral popliteal arteriograms were made on the operating table to be certain that there was adequate distal reconstitution, as shown in Figure 1*B*. While the films were being developed, the femoral artery was exposed in each thigh. As soon as the films were available and it was recognized that the distal vessels were suitable for grafting, an abdominal incision was made in the midline. After the right colon was reflected upward and the ureters were located, a bifurcation homograft was removed from the freezer, and to it were sutured femoral grafts from two other patients, as illustrated in Figure 2, where the graft is shown laid out on the patient in the operating room just prior to its placement. The atherosclerotic distal aorta and a small segment of the iliac vessels was excised and the iliac vessels tied off with 00 silk. The homograft was now sutured to the proximal aorta in the usual

Fig. 3 (Case 1).—Black area on left shows extent of thrombotic lesion, while right shows the three grafts used for vascular replacement.



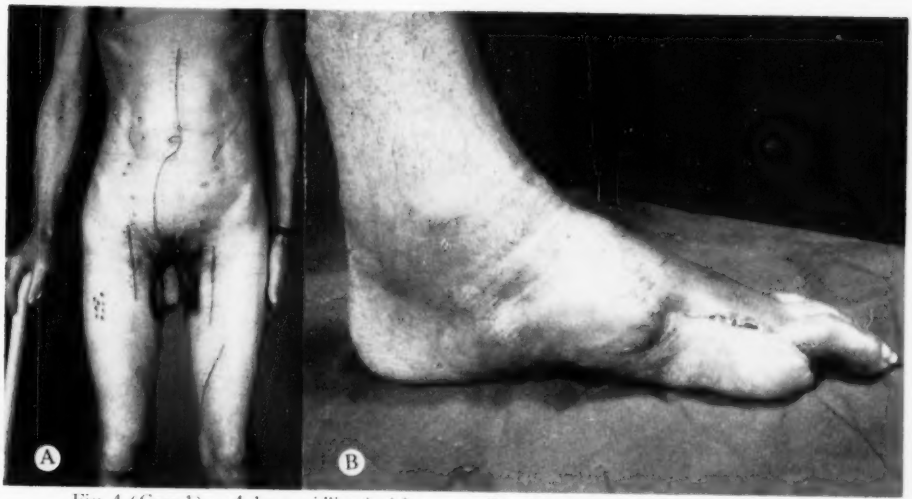


Fig. 4 (Case 1).—*A*, long midline incision, as well as bilateral femoral and popliteal incisions, which are well healed. The old bilateral sympathectomy incisions are just visible in the upper quadrants of the abdomen. On the right thigh are pinch-graft scars.
B, well-healed left foot following metatarsal phalangeal amputation.

fashion by a continuous 0000 silk suture, interrupted in three places. The right and left femoral limbs, respectively, were pulled down through the proximal thigh incisions and on through tunnels into the distal thigh incisions, carefully so that they were not twisted in the longitudinal axis. These limbs were now sutured end-to-side to the proximal popliteal arteries. Figure 3 illustrates the lesion and the graft reconstruction. Clamps were removed, and all blood vessels began to pulsate as expected. After approximately 15 minutes it was noted that the left femoral artery had ceased to pulsate, and a clot was found to be building up from the anastomosis at the left popliteal artery in a proximal direction. The distal end of the graft on the left was opened and this clot removed by suction with a closely fitting polyethylene cannula placed inside. After about 45 minutes of suction and heparin irrigation, the graft was closed, with an excellent pulsation. All wounds were closed, and the patient was returned to the ward in good condition. Fifteen hundred cubic centimeters of blood was transfused during this operation.

In the immediate postoperative period both femoral grafts could be felt pulsating well in the thighs, but no pulses could be felt distally and the oscillometer did not show any flicker below the knees. The feet, however, became rapidly warmer, and the capillary return was good. On the following day a flicker of oscillation developed at both calves, and 48 hours after operation a right dorsalis pedis pulse became palpable. The further convalescence was uneventful. Because of the ulceration of the distal part of the left foot, a local amputation was performed by Dr. James A. Deweese on Aug. 7, with immediate primary healing (Fig. 4*B*), although a dorsalis pedis pulsation has never returned to the left side. Within two months there began to be an excellent growth of hair on both lower legs, and the nails changed character. He was able to return to work part time three months after operation and full time four months after operation, wearing a special shoe to compensate for the loss of the left metatarsal and toe. Eight months postoperatively all pulses were present and his status was excellent.

Comment.—This patient had been completely incapacitated prior to grafting and was returned to his normal occupation following the operation and amputation of the gangrenous toe. Since distal reconstituted vessels had not been demonstrated at the time of aortography, the first operative procedure was to expose the popliteal vessels to be certain that these would take a graft prior to making an abdominal incision. Immediate thrombosis fortunately responded to endarterial thrombectomy on the left, and pulses returned on that side in the late postoperative period. No new blood supply could be arranged to the pelvis; so the preoperative loss of sexual function was not improved by operation.

Case 2.—A 71-year-old white man was admitted Sept. 8, 1957, because of vascular insufficiency in the left foot and ankle, characterized by a red,

painful foot, which had become considerably more painful in the previous five or six days.

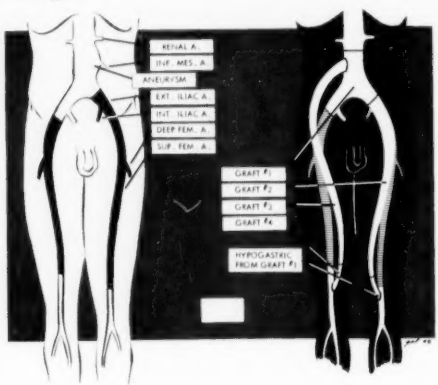
The patient had been examined in the office three days previously, at which time, because there were no pulses at any point in either extremity and the oscillometer showed only a half-unit of oscillation in the thighs, it was thought that there was thrombosis of the aortic or iliac system secondary to atherosclerosis and that, because of the patient's previous history of multiple bouts of pulmonary edema and myocardial infarction, a graft replacement operation was contraindicated. During the patient's hospitalization, after long discussion with the family, the patient himself, and the referring physician, it was finally decided to attempt a graft if arteriograms indicated that this was feasible.

On Sept. 10, an aortogram (left side, Fig. 5) showed that there was a complete cut-off on the left common iliac artery, with no filling at any point below. The right common iliac artery was scalloped (as was the aorta) but did not fill with dye, as did the internal iliac artery. The right external iliac, however, was completely blocked, and all circulation in the pelvis was being carried through the right hypogastric artery. A later film of the lower leg did show the distal superficial femoral artery to be patent at a point above the knee. Two days later a left femoral arteriogram was obtained through an operative incision in the femoral triangle (right side, Fig 5), and, although there were extensive scalloping and multiple blocks in the left superficial femoral artery down to the level of the knee joint, the distal popliteal artery was open and appeared adequate to allow sufficient run-off for a graft to be feasible.

Fig. 5 (Case 2).—Aortogram on left showing dye in distal aorta and right common iliac, as well as in right hypogastric. Although the deep femoral artery is outlined, there is a long block down to the lower arrow, where the popliteal artery on the right is reconstituted. On the left there is entire absence of a vascular tree. The left open operative arteriogram showed thrombosis in the femoral system, but a patent distal popliteal system.

After further discussion, the patient was operated upon on Sept. 13. Initially, he lay on his left side so that the right leg could be swung in either direction, and, with the right leg swung over anterior to the left leg, the left popliteal space was explored, and patency of the distal popliteal artery was determined. The patient was now rolled onto his back. The abdomen was opened through the usual midline incision, the right colon reflected, and the aorta dissected with the hope that a shunt graft could be applied between the aorta and, after being pulled down through the leg, the popliteal artery. However, it was now found that there was a small aneurysm of the distal aorta (diagram, Fig. 6), and it was thought too dangerous to graft to this or near it. Because of this, the aortic dissection was continued so that the entire bifurcation could be replaced. A frozen homograft was placed between the proximal aorta and the common iliac on the right, and this was sutured to a second frozen homograft on the left and that tunneled down beneath Poupart's ligament through an incision in the thigh and joined, as shown in Figure 6, end-to-side to the popliteal

Fig. 6 (Case 2).—Extent of the lesion on the left and the four grafts used to replace this on the right.



artery on the left. Because the two grafts sewn together were not quite long enough to reach a satisfactory place on the popliteal artery, the hypogastric vessel which had been cut away from the first graft (the aortic bifurcation graft) was sewn onto the end of the second graft. This left side was now opened and blood allowed to flow through. Pulsation was good. Since the procedure was being tolerated fairly well, a third graft was now placed end-to-side between the first graft and the distal superficial femoral artery on the right, using a small segment of a fourth graft, as shown in Figure 6.

At conclusion, although both sides had been pulsating well, the right side became thrombosed and it was necessary to open the femoral wound and remove clot with an endarterial cannula. After this, the same was necessary on two different occasions on the left. This prolonged the operation, but at length all wounds were closed and the patient was returned to the floor in fairly good condition after this eight-hour operation, which was considerably more extensive than had originally been contemplated, because of the unsuspected aneurysm necessitating bifurcation grafting, and particularly because of the thrombosis occurring in the femoral parts of the graft.

Postoperatively, the right leg was warm, but the left leg was cool from the knee down. It was thought that thrombosis had probably occurred in the lower calf during the time that circulation to the left leg had been interrupted (46 minutes). The following morning the patient was alert, with good vital signs, and was passing small amounts of urine (568 cc. on the first postoperative day). He began to tolerate fluids orally over the next 48 hours. On the night of the fourth postoperative day, there was a sudden change in the level of consciousness, and he appeared moribund, with lowered blood pressure and tachycardia. The urinary output became negligible. He died the following day, in extreme oliguria, failing to recover from pulmonary edema. It had become apparent that the left leg would be lost below the knee because of gangrene, although the remainder of the graft appeared to be functioning. Permission for autopsy was refused.

Comment.—Initially, the severe risk of this physiologically very old man was recognized, and operation was refused; but, because of the desperate situation of the left leg, it was finally agreed to attempt a shunt from the aorta to the popliteal artery on that side if an operative arteriogram showed proper distal reconstitution. At the actual operation a small, unsuspected aneurysm of the abdominal aorta necessitated resection rather than simple shunting. The difficulties with clotting within the grafts, detailed in the case report, added a considerable time to the operative procedure. However, he did fairly well, although the left leg was in jeopardy, until his sudden downhill course. In retrospect, it was apparent that his limited reserve would not have allowed recovery from even the slightest postoperative complication and his death ensued.

CASE 3.—A 54-year-old white man was hospitalized Jan. 17, 1958, because of progressive dry gangrene of the right great toe, of about two months' duration. Prior to this he had had bilateral calf claudication for several years, but he had tolerated this very well until the gangrene occurred. There had been occasional night pain in the calves. The right great toe had been extremely painful three weeks prior to admission, and he had been unable to wear shoes since then. On examination, no pulses were found at any point in the legs except for a very weak left femoral pulsation. The oscillometer failed to show any motion at all except for a flicker in the left thigh. The legs were pale in the prone position and cadaveric on both sides when elevated.

On Jan. 20, injection of 5 cc. of 50% diatrizoate sodium was made into the aorta, from which a feeble stream of blood was obtained. Figure 7*A* shows that this dye immediately dumped into the hepatic and splenic arteries and did not fill out the aorta. This was interpreted as evidence of aortic occlusion, and it was judged too risky to place further dye into the aorta. Two days later both femoral arteries were exposed in the operating room and a polyethylene catheter was inserted into each. Figure 7*B* shows the arteriogram obtained on the left, indicating a patent femoropopliteal arterial system. On the right there was inability to find a lumen, indicating that the right femoral system was occluded. Two days later the right proximal popliteal artery was exposed, and through a No. 18 needle 10 cc. of 25% diatrizoate sodium was injected and the arteriogram seen in Figure 7*C* made. This indicated patency of the distal popliteal artery and tibial vessels.

Aortic resection and grafting were performed Jan. 27. When the abdomen was opened, the entire aorta distal to the renal vessels was seen to be thick and to contain a solid thrombus. The left iliac artery was completely fibrotic and small, and the right iliac artery was thrombosed but not fibrotic (Fig. 8). Dissection was carried up and the aorta clamped just distal to the renal arteries and cut across. The posterior part of the anastomosis between the proximal aorta and a coned Tapp-Edwards crimped nylon graft[a] was now laid

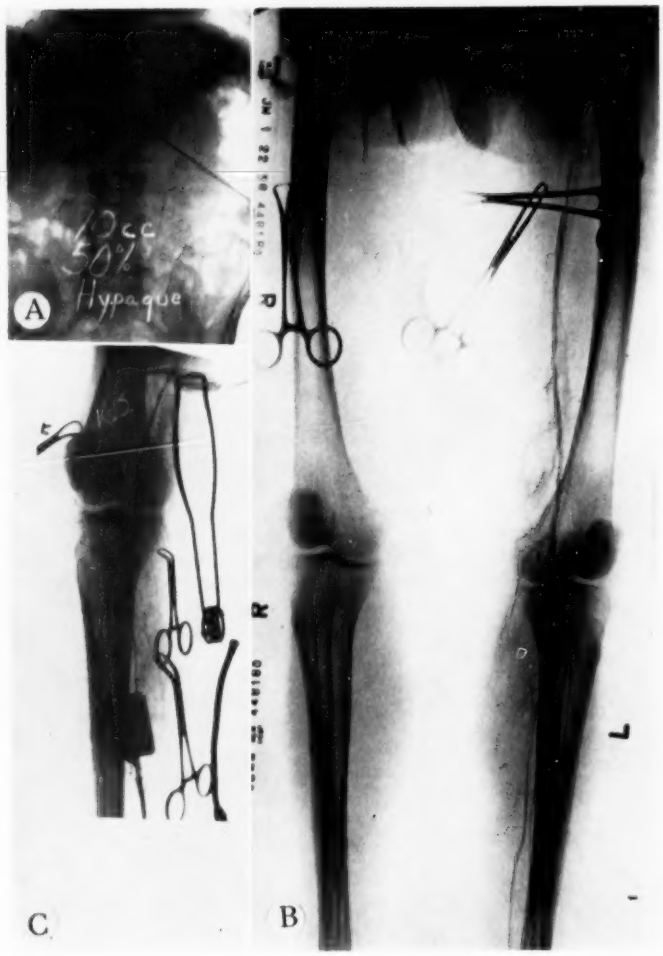
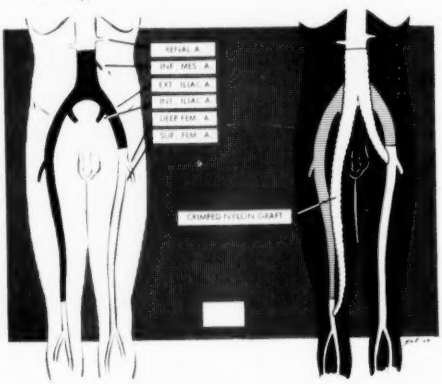


Fig. 7 (Case 3).—*A* (upper left), aortogram failing to delineate. *B* (right), operative femoral arteriogram with open left femoral artery. *C* (lower left), operative right popliteal arteriogram.

The proximal aorta was endarterectomized after removing the clamp and controlling blood loss by a finger above the renal vessels. During this period a clamp was placed across the graft to prevent any clots being washed down to the interior of the nylon graft. After the proximal endarterectomy was completed, the aortic clamp was replaced and the remainder of the aorta to the graft anastomosis finished with a continuous 0000 silk suture. The distal aorta was resected and the thrombosed iliac arteries left in place. The left limb of the prosthesis was then pulled through a tunnel under the ureter, sigmoid colon, and left Poupart's ligament and anastomosed end-to-side to the left superficial femoral artery with continuous 00000 silk sutures, interrupted by mattress sutures at either end of the anastomosis. The right limb of the prosthesis was tunneled underneath the right ureter and

Fig. 8 (Case 3).—Extent of the lesion on the left and the method of crimped nylon replacement on the right.



Poupart's ligament, passed down through the femoral incision, and tunneled to the popliteal space, where it was anastomosed end-to-side to the popliteal artery by similar technique. The lesion and the graft are illustrated in Figure 8. Good pulses were present after the clamp was removed, and there was a minimal loss of blood through the preclotted graft. Appendectomy was performed and about 30 minutes allowed to pass, with the graft pulsating well. Wounds were now sutured.

Immediately, there was a three-quarter oscillation in the right calf, but none on the left. However, after an hour, the left dorsalis pedis pulse became palpable, and the right foot became hot and red. Later that evening all pulses became palpable.

On the ninth postoperative day the right great toe was amputated and the wound healed per primam. Convalescence was thereafter uneventful, and the patient was discharged on the 21st postoperative day, in good condition. On examination in the office two months after operation, the amputation wound was well healed, and he was walking with a slight limp. All his pulses were excellent, and he was generally in good condition.

Comment.—The patient was initially hospitalized for amputation but agreed to the study with the hope that grafting might be feasible. Three different arteriographic examinations were finally necessary to determine absolutely that there were distal reconstituted vessels to which a graft might be sutured. Because of previous time consumed by suturing multiple grafts together for the first two patients, and because of growing dissatisfaction with homologous arterial grafts in general,[2] it was decided to use a synthetic in this patient. No difficulty was encountered, and his postoperative course was not remarkable.

General Comment

Although extensive vascular replacement as cited is not often necessary, it is useful with certain patients. Certain points are worthy of emphasis.

Arteriographic Diagnosis.—The aortogram must, of course, show patent distal peripheral vessels to allow successful grafting. In general, the aortic injection of radiopaque substances should be avoided because of associated risk. Such injection in cases where a distal aortoiliac block is probable may allow prolonged pooling of hypertonic dye in the aorta or force it back into important smaller vessels. After seeing fresh, completely occluding thrombus while we were operating upon two patients with recent injections, the use of this aortic examination was curtailed sharply. Often a 5 cc. injection of dye will serve the same purpose in the aorta and iliac vessels as a larger amount, while the distal vessels may be investigated by direct operative arteriograms at the time of operation.

The true nature of atherosclerotic occlusion of the aorta may often be suspected from the feeble stream which ejects from the aortographic needle when this is placed, and may be confirmed by the small 5 cc. test dose of 50% diatrizoate sodium. It is thought to be considerably safer to stop the examination with this information and proceed further by direct exposure of either femoral or popliteal vessels than to force a full dose of dye into the aorta, hoping that it will run around through collaterals and thus delineate the distal "run-off" system. Figures 1, 5, and 7 illustrate how the combination of careful aortography and operative peripheral arteriography may be used to delineate accurately the vascular situation.

Operative Sequence.—The procedure by which the distal vessels are initially dissected, tunnels made, and rubber drains tunneled through allows much of the work to be done prior to the time the abdomen is opened. The intra-abdominal portion of the operation can be performed next, followed by suture of grafts to the distal vessels. Abdominal closure preceding thigh-wound closure allows more time for inspection and palpation of the grafts, to be certain that they remain open and pulsating for a reasonable time before final closure. The importance of a proper time period for continued inspection and palpation of the graft after placement is illustrated by the development of intravascular thrombosis in Case 1, in which the thrombus was immediately recognized and successfully cleared.

Graft Preparation and Orientation.—The task of homograft preparation and suture of several grafts together should be assigned

to another team, if possible, to decrease total anesthesia and operation time. Tangential trimming of the ends of each segment allows a wider lumen at anastomoses and prevents a small circular anastomosis. Each distal end should be carefully marked with regard to the longitudinal axis prior to tunneling through and care taken to avoid twisting, thereby compromising the vascular lumen. This may be accomplished by placing a tied suture, with ends cut long, through the anterior wall of the end of each femoral segment prior to tunneling this graft through into the thigh. If the distal end of the femoral segment then be placed within the lumen of a soft rubber drain and tied carefully therein, the limb is easily pulled through the tunnel without catching on various tissue structures. The slightly traumatized distal end may then be trimmed away. As a final check, each femoral segment should be inflated with saline from an Asepto syringe to be certain that there is free passage and no twisting on the longitudinal axis.

Analysis of experience here with arterial homografts [2] indicates that early, as well as late, difficulties occur with homologous arterial transplants which do not occur with synthetics. It appears, therefore, that the latter (synthetic grafting materials) will replace the use of homografts. The decreased operating time in Case 3 herein presented, as compared with that in Cases 1 and 2, is a great advantage in a synthetic graft.

Grafts at Flexion Creases.—The femoral segment was in each instance tunneled beneath Poupart's ligament directly anterior to the femoral artery or anteromedial to this. By placing a finger underneath the ligament, it was ascertained that there was no great amount of constriction, and so no incision was made into the inguinal ligament, although this could be done very easily if it appeared necessary. The more distal tunneling through the adductor magnus muscle seemed preferable to dissecting down through the original hiatus in this muscle, where the tendinous insertion might tend to kink later. The muscle was simply split widely at a convenient point in order to allow the graft to pass easily.

Destruction of Existent Collateral Channels by Operation.—Particular consideration was given to the possible destruction of collateral channels at operation, and in the event that some portion of the operation failed to be successful. In the first case the aortogram had indicated that there were no main vessels carrying blood to the pelvis, and this finding was confirmed at operation. The distal aorta was removed as a specimen to enable the aortic replacement to lie easily in the retroperitoneal space, but the iliac vessels were left undisturbed in order to preserve whatever collateral circulation was present in the pelvis. The femoral incisions indicated that both femoral arteries were solidly occluded also, and so this patient now carries blood directly from the aorta to the proximal popliteal vessels without any channels flowing from the graft into the pelvis or into the thighs, which are apparently nourished by the same collaterals which were present preoperatively. Fortunately, this patient had no thigh or buttock claudication prior to operation, and the calf claudication was, of course, relieved by the restoration of blood flow through the graft, as was the healing capacity of the foot, as indicated by the successful amputation and the growth of new nails. His sexual function was not changed at all by operation. He was almost impotent prior to operation and has been so since.

The common iliac artery in Case 2 was furnishing blood to the hypogastric artery on the right, and numerous channels were coursing from this vessel throughout the pelvis. When, because of the discovery of the aneurysm, it appeared necessary to resect the bifurcation of the aorta rather than simply to shunt to the left leg, it was thought that the first consideration should be given to immediate restoration of blood flow to this right common iliac artery. As Figure 6 shows, the right side of the bifurcation graft was anastomosed end-to-

end to this common iliac artery to restore pelvic blood flow via the hypogastric artery. Later, since the operation had proceeded well, it was decided to go ahead with a shunt from the graft down to the right distal superficial femoral artery, and this was done, as indicated in the case protocol. This patient did not survive long enough for any observations regarding pelvic blood flow to be made.

Removal of Thrombosis from Within the Graft.—In the first two instances thrombosis occurred within some portion of the graft, for an unknown reason. Since the original anastomoses had appeared to be completely satisfactory and it seemed doubtful that a better one could be made by dismantling, and because in two previous cases such a thrombus had been successfully removed by opening the graft itself, this maneuver was carried out. A snugly fitting polyethylene catheter was selected from a set of intra-arterial cannulae and passed in both directions to remove this thrombus and irrigate thoroughly with heparinized saline. After removal of the polyethylene tube, the arteriotomy in the distal end of the femoral portion of the graft was closed with a continuous 00000 silk suture. In Case 1, after this maneuver there was no further difficulty with thrombosis, and the patient obtained an excellent result. In Case 2 such a result was apparently obtained on the right side, but demarcation of the left leg below the knee seemed to indicate that the graft had become thrombosed somewhere below the femoral region in the immediate postoperative period. The cause of these thromboses in both these patients is not clear. Such a thrombus has occasionally occurred previously in other femoral bypassing grafts and in two instances has been successfully removed by a similar maneuver. As indicated above, it appears better to allow 30 to 60 minutes to elapse, during which time the graft can be carefully observed, and, while other wounds are being closed, to be sure that thrombosis does not occur, rather than possibly to delay removal of such a thrombus if it occurs at the time that the patient is in the recovery room. There was no difficulty with the third case.

Summary and Conclusions

Three cases of extensive replacement of the distal aorta and iliofemoral systems are discussed to illustrate the feasibility of operation in properly selected cases.

The importance of accurate preoperative arteriographic diagnosis is emphasized. Restriction of dye injected into the proximal aorta and use of open operative distal arteriograms are indicated.

While multiple sutured homologous arteries may be used, it is currently believed that these will be superseded by synthetic materials.

2118 West End Ave. (5).

Addendum

Since preparation of this article the use of homologous arterial transplants has been replaced by synthetic tubes for large vessel replacement.

REFERENCES

1. Crawford, E. S.; Creech, O., Jr.; Cooley, D. A., and De Bakey, M. E.: Treatment of Arteriosclerotic Occlusive Disease of the Lower Extremities by Excision and Graft Replacement or By-Pass, Surgery 38:981 (Dec.) 1955.

2. DeWeese, J. A.; Woods, W. D., and Dale, W. A.: Complications of Arterial Homografts, to be published.

3. Edwards, W. S., and Tapp, J. S.: Chemically Treated Nylon Tubes as Arterial Grafts, Surgery 38:61 (July) 1955.

4. Laufman, H.; Hohf, R.; Bernhard, V., and Trippel, O.: End-to-Side Bypass Homograft Without Resection in Segmental Arterial Occlusion, A. M. A. Arch. Surg. 73:418 (Sept.) 1956.

5. Linton, R. R., and Menendez, C. V.: Arterial Homografts: A Comparison of the Results with End-to-End and End-to-Side Vascular Anastomoses, Ann. Surg. 142:568 (Oct.) 1955.

6. Rogoff, S. M.; Dale, W. A., and DeWeese, J. A.: Angiography in the Surgical Management of Peripheral Atherosclerosis, to be published.

Gastric Trichobezoar

Report of a Case

C. HERBERT FREDELL, M.D., Flagstaff, Ariz.

In 1779 Baudamant reported the first case of a gastric trichobezoar in a 16-year-old youth. The first successful removal of a gastric trichobezoar recorded was described by Shonborn in 1883. Three years later Thornton reported the first correct preoperative diagnosis of a hairball in the stomach.

De Bakey and Ochsner,[2] in a comprehensive review of the literature in 1938, collected 303 cases of various types of bezoars of the stomach and intestine. In 1957 Mullen[3] reviewed the literature, finding 211 cases of gastric trichobezoars. He noted that 80% of these cases occurred before the age of 30, and that 90% of the cases occurred in females. The great number of cases occurring in females has been attributed to their greater hair length and greater psychoneurotic tendencies. It is of interest, however, that only 14% have been reported in persons with proved mental illnesses.

The etiology of a gastric trichobezoar is trichophagia. Generally, symptoms are only evident when the bezoar becomes large enough to interfere with nutrition, produce obstruction or ulceration, or present as a palpable mass. Occasionally a case may be suspected in alopecia of undetermined origin.[4] The finding of a movable mass in

Chief of Surgery, Flagstaff Hospital.
Submitted for publication Dec. 11, 1958.

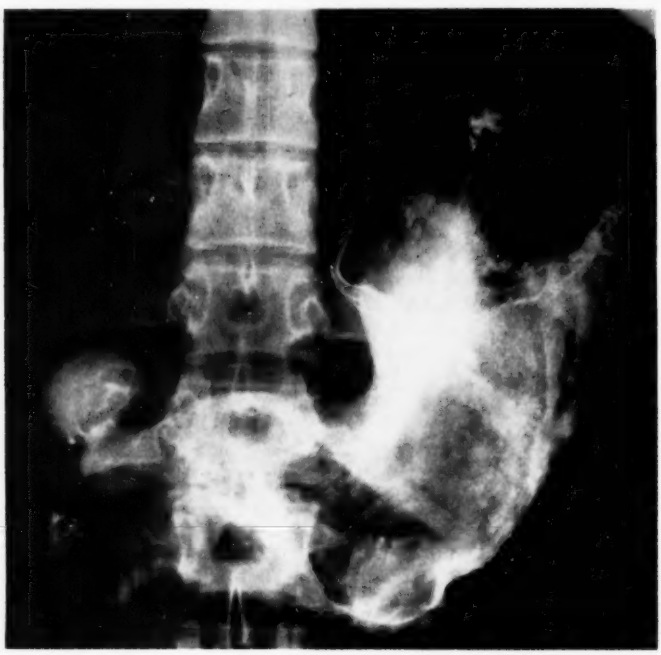


Fig. 1.—An upper gastrointestinal barium study shows the trichobezoar clearly prior to surgery.

the left upper quadrant of the abdomen often leads to roentgenologic examination, which confirms the diagnosis of a gastric hairball.

The treatment is surgical removal through a gastrotomy. Great care must be taken at the time of operation to avoid contamination of the peritoneal cavity, because the bezoar contains a mixture of virulent micro-organisms. The surgical removal of a gastric trichobezoar is associated with a mortality of less than 4%, while the untreated case of bezoar has a mortality of 50% to 70%. This high mortality is due to starvation, intestinal obstruction, ulceration with perforation, and hemorrhage.[4] An uncommon complication of gastric polyps, with malignant degeneration of one of the polyps, associated with a gastric trichobezoar has been reported.[1]

Report of Case

A 16-year-old girl was admitted to the Flagstaff Hospital on Sept. 27, 1958, with the complaints of persistent vomiting of four days' duration, accompanied by vague epigastric pain.

Fig. 2.—The trichobezoar is being delivered through a gastrotomy. Care was taken to avoid contamination of the peritoneal cavity, since these foreign bodies often contain virulent organisms.

Fig. 3.—The specimen is shown to be a near-complete cast of the stomach.

Her past history revealed that she had been seen by a dermatologist two years previously because of alopecia. Further inquiry into her habits revealed that she twined hair about her tongue frequently in the past, but she denied any ingestion of hair. She had had an appendectomy two and one-half years before, and she had had numerous procedures during the past 10 years for correction of strabismus. She denied vomiting any hair and did not notice any hair in her stools.

Physical examination revealed a freely movable mass, 4-in. diameter, in the left hypochondrium. Roentgen-film examination of the abdomen revealed an intragastric mass, outlined by air. Barium studies confirmed the presence of a mass within the stomach, which appeared to be a trichobezoar (Fig. 1).

On Sept. 28, 1958, a gastrotomy, with removal of a large trichobezoar, was performed (Figs. 2 and 3). Her postoperative course was uneventful, and she was discharged from the hospital on Oct. 4. She was referred to a psychiatrist for further care.

Comment

This case demonstrates the typical chain of events that leads one to suspect from the history and confirm by physical examination and x-ray studies a gastric trichobezoar.

The surgical treatment was removal of the offending mass of hair. It should be emphasized that the treatment of the patient was not terminated when she was discharged from the hospital. This entity represents serious psychiatric disease and should be treated with that in mind. The surgeon treats only a manifestation of a complex psychiatric problem.

Summary

A case of gastric trichobezoar is presented. Approximately 212 cases have been reported in the literature to date.

The importance of psychiatric care is greater than the surgical episode in a case of gastric trichobezoar.

121 E. Aspen Ave.

REFERENCES

1. Charache, H., and others: Trichobezoar: Report of a Case of Gastric Trichobezoar Complicated by Multiple Polyps with Malignant Degeneration of One of the Polyps, Ann. Surg. 145:282-286 (Feb.) 1957.

2. De Bakey, M., and Ochsner, A. O.: Bezoars and Concretions: A Comprehensive Review of Literature with Analysis of 303 Collected Cases and Presentation of 8 Additional Cases, Surgery 4:934 (Dec.) 1938.

3. Mullen, J. E.: Trichobezoar: Survival Following Complication of Perforated Ulcer, Ohio M. J. 53:41-44 (Jan.) 1957.

4. Tondreau, R. L., and Kirklin, B. R.: Symposium on Abdominal Surgery: Bezoars of the Stomach, S. Clin. North America 30:1097-1108 (Aug.) 1950.

Blood Pressure Changes in Paraplegics During Urological Manipulations

RODNEY A. MANNION, M.D.; THOMAS L. C. COTTRELL, M.D., and FREDERICK A. LLOYD, M.D., Hines, Ill.

Excessive sympathetic reactions occur in patients with injuries of the spinal cord following stimuli below the level of anesthesia. One of the most dramatic changes involves the cardiovascular system, in particular, the blood pressure.[5] This report is concerned with blood pressure changes in a group of paraplegics which were produced by various urological procedures carried out at the Veterans Administration Hospital, Hines, Ill. The blood pressure changes are compared with those in patients without demonstrable spinal cord disease, undergoing similar procedures.

An attempt is made to define some of the hazards encountered in treating the paraplegic for urological disease, especially in regard to anesthetic difficulties which may stem from these procedures.

Data

Blood pressure changes were studied in 121 patients, 61 of whom were paraplegic. Of the latter, 27 had cervical cord lesions; 18, upper thoracic lesions; 9, lower thoracic lesions, and 7, lumbar cord dysfunctions. Sixty patients had no spinal cord disease, but presented various urological complaints of medical or surgical nature. The blood pressure was taken on each patient prior to and directly after such a procedure. Analysis of the mean pressure changes can be seen in Tables 1 and 2. Both systolic and diastolic values rose to higher levels in patients with cervical cord dysfunction than in either patients with lower cord lesions or in normal patients. The systolic blood pressure rose 18.9 mm. Hg in the cervical group, whereas the patients with no spinal cord disease had an actual drop of 5.4 mm. It is seen in Table 2 that the mean rise of diastolic pressure in cervical cord patients is 13.2 mm., while a drop in blood pressure was seen in most of the other groups. There was essentially no change in the diastolic pressure noted in normal patients.

TABLE 1.—*Mean Systolic Blood Pressure Changes with Instrumentation*

Level of Lesion	Mean Systolic B. P. Change with Instrumentation
Cervical	+18.9
Upper thoracic	+ 1.2
Lower thoracic	− 1.8
Lumbar	− 2.4
Nonparaplegic (normal)	− 5.4

A statistical analysis of the data, using Fisher's Table of F Variance Ratio, as summarized in Table 3, indicates that the variance for patients with cervical cord disease prior to urological manipulation, as compared with the same group after manipulation is 7.19. The comparable value for normal patients is only 0.18. A similar variance curve was derived for diastolic pressure differences. These values indicate a definite statistical significance.

Comment

The physiology of the sympathetic response has been the subject of a number of theories and postulations. There are two main pathways mediating response from the bladder and the spinal cord. Impulses are carried through the sympathetic and parasympathetic divisions of the autonomic nerv-

Submitted for publication Dec. 12, 1958.

Spinal Cord Injury Section, Department of Urology, Veterans Administration Hospital.

TABLE 2.—*Mean Diastolic Blood Pressure Changes with Instrumentation*

Level of Lesion	Mean Diastolic B. P. Change with Instrumentation
Cervical	+13.2
Upper thoracic	+ 0.4
Lower thoracic	− 3.3
Lumbar	+ 3.0
Nonparaplegic (normal)	− 0.1

TABLE 3.—*Fisher's Table of F Variance Ratio*

Source of Variation (VS) *	Degree of Freedom, *d. f.*	Sum of Squares (*SS*)	Mean Square (*MS*)	Variance Ratio (*F*)
A compared with B	1	5,221.5	5,221.5	**7.19**
C compared with D	1	603.0	603.0	0.83
A+B compared with C+D	1	130.5	130.5	0.18
Within groups (error)	170	123,544	726.7	
Total	173	129,499		

* A indicates cervical lesion patients prior to instrumentation; B, cervical lesion patients after instrumentation; C, normal patient prior to instrumentation; D, normal patient after instrumentation.

ous system. The sympathetic impulses arise from the intermediolateral cell column of the lower thoracic and upper lumbar cord and pass through white rami to the paravertebral ganglia. The preganglionic fibers synapse with postganglionic fibers, and these, in turn, contribute to the formation of the hypogastric plexus and the presacral nerve. The parasympathetic nerves originate in the intermediolateral cell column of the second, third, and fourth sacral segments. These preganglionic fibers pass through the pelvic nerves and synapse on the bladder itself. Somatic fibers from the second, third, and fourth sacral segment levels form the pudendal nerve, which innervates the perineum.

Visceral afferent fibers travel through the sympathetic, parasympathetic, and somatic nerves and are not considered an integral part of the autonomic nervous system. The detrusor muscle is activated by impulses which pass through the sacral nerves of the parasympathetic autonomic system. Both autonomic and somatic pathways are utilized when the urethra and bladder are stimulated by urological manipulation. The centers controlling vasoconstriction and vasodilatation are located in the medulla and pass down the cord in the anterior part of the lateral columns and terminate in the intermediolateral horns.[1,3]

Statistics analyzed in this report indicate that the response to sympathetic stimulation is greater in the patients with cervical cord lesions. The exact mechanism which causes a rise in blood pressure in these patients remains obscure. There are, however, a number of factors involved. Mass reflexes, which are found in the paraplegic, are due to a periodic increase in the degree of facilitation of the anterior horn cells. The blood pressure response is not necessarily associated with a massive contraction of skeletal muscle. There is evidence to show that an inhibitory area is located in the lower pons and in most of the medulla. A cervical cord lesion abolishes the inhibitory impulses, allowing unimpeded stimulation below this area. Excision of the scarred portion of the upper cord usually abolishes the mass reflexes, indicating that impulses are initiated in the scar tissue itself as a result of nerve fiber compression.[4]

Clinically, catheter blockage, bladder or bowel distention, acute genitourinary infection, or simple tactile sensation to the skin may elevate the blood pressure. Surgical procedures can produce hypertension of such degree as to test the ingenuity of the surgeon and anesthetist in preventing a cardiovascular accident. The rise in blood pressure associated with vasomotor instability of small blood vessels increases hemorrhagic tendencies. Consequently, the mere changing of a catheter, instrumentation of the urethra, or transurethral resection may be particularly troublesome.[2,6,7] These factors, associated with the poor surgical risk in these patients, increase the morbidity and surgical mortality in paraplegics.

Summary

Blood pressure responses to various urological procedures were examined in 121

patients, 61 of whom were paraplegics. Statistical analysis showed significance of a heightened response in patients with neurological lesions.

Paraplegics with spinal levels below the cervical area tend to react as do normal patients. Those with cervical cord dysfunction were found to have impressive blood pressure elevation, even during simple, clinical procedures.

A number of factors which affect the sympathetic reaction are presented.

We acknowledge the assistance of Mr. Phillip Zinkgraf and Dr. Lionel M. Bernstein, of the Veterans Administration Hospital.

Department of Urology, Veterans Administration Hospital.

REFERENCES

1. Anson, B. J., and Maddock, W. B.: Callander's Surgical Anatomy, Ed. 3, Philadelphia, W. B. Saunders Company, 1952, p. 546.

2. Bors, E., and French, J. D.: Management of Paroxysmal Hypertension Following Injuries to Cervical and Upper Thoracic Segments of the Spinal Cord, A. M. A. Arch. Surg. 64:803-812, 1952.

3. Fulton, J. F.: Physiology of the Nervous System, Ed. 3, New York, Oxford University Press, 1949, p. 175.

4. Guyton, A. C.: Textbook of Medical Physiology, Philadelphia, W. B. Saunders Company, 1956, pp. 631-632.

5. Head, H., and Riddoch, G.: Automatic Bladder, Excessive Sweating and Some Other Reflex Conditions in Gross Injuries of the Spinal Cord, Brain 40:188-263, 1917.

6. Hutch, J. A.: A Study of the Hyperactive Autonomic Reflex Initiated by Bladder Distention in Patients with Lesions in the Cervical and High Thoracic Cord, J. Urol. 73:1019-1025, 1955.

7. Thompson, C. E., and Witham, A. C.: Paroxysmal Hypertension in Spinal Cord Injuries, New England J. Med. 239:291-294, 1948.

Acute Intestinal Obstruction Secondary to Postoperative Adhesions

EDWARD M. MILLER, M.D., and JAMES M. WINFIELD, M.D., New York

During recent years, some quarters have expressed dissatisfaction with the conservative approach to the treatment of acute intestinal obstruction secondary to postoperative adhesions. The principal reasons offered for advocating immediate or early surgery, rather than intestinal intubation, are that (1) strangulating obstruction cannot be diagnosed correctly in 100% of cases, and that (2) delay in those cases misdiagnosed carries risks that outweigh advantages gained by conservative decompression, i. e., intestinal intubation with the long tube. Our point of view on the surgical services of the New York Medical College-Metropolitan Hospital Center has been one of moderation. Only a minority of patients with acute adhesive intestinal obstruction have been treated with immediate or early operation without benefit of prior intestinal intubation and decompression; these have been patients suspected of having strangulating obstruction. At this time it seemed appropriate to evaluate a recent series of cases of acute adhesive intestinal obstruction in order to assess the justifiability of our present concepts of therapy.

Material and Methods

The files of the Flower and Fifth Avenue and Metropolitan Hospitals were examined in order to secure cases of acute intestinal obstruction resulting from postoperative adhesions. Only those cases which demonstrated radiographic as well as clinical evidences of acute intestinal obstruction were acceptable. In each case, the roentgenograms demonstrated distended loops of bowel and/or fluid levels, and the roentgenologist's impression was that of "mechanical intestinal obstruction." Sixty-three consecutive cases of adhesive intestinal obstruction form the basis of this study.

Submitted for publication Dec. 15, 1958.

From the Department of Surgery, New York Medical College-Metropolitan Hospital Medical Center.

Results

Incidence.—There were 48 women and 15 men, a ratio of 3.2:1. The average age of the patients was 50, the oldest being 85 and the youngest 6 years. The average age of the men was 42, whereas it was 52 in the female group. There were 44 white and 19 Negro patients.

Interval Between Operation and Obstruction.—In 14 cases the episode of acute obstruction was a complication occurring in the immediate postoperative period, i. e., while the patient was convalescing in the hospital after an abdominal or a pelvic operation. These cases are to be termed the "early" group of obstructions. In this group, there were 12 women and 2 men, a ratio of 6:1. In the "early" cases, the average interval between the operation and a full-blown obstruction was 7.5 days. However, obstructive symptoms were noted in less than four days in half the cases.

There were 49 cases in which intestinal obstruction occurred some time after hospital discharge following a previous abdominal or pelvic operation. These are to be termed "late" cases. In this group, the average interval between the original operation and the episode of obstruction was 10.5 years, with a span of 1 month to 39 years. In more than one of four of the "late" cases intestinal obstruction developed within one year after the primary operation.

Previous Abdominopelvic Operations.—Of the 48 women with acute intestinal obstruction, 32 (66.7%) had had previous pelvic operations, 16 of which were abdom-

inal hysterectomies. In 25% of instances the primary procedure had been a pelvic operation, followed after varying intervals by a second abdominal or pelvic procedure.

Eighteen patients (28.6%) had undergone appendectomy at some time previously; in 53.3% of the male patients, appendectomy was the precursor of the intestinal obstruction.

Nine patients (14.3%) had undergone previous colon surgery, of whom four had an abdominoperineal resection, four a sigmoidectomy, and one a right hemicolectomy.

Cholecystectomy was the previous operation in seven cases (11.1%). In three instances it had been the only abdominal operation, and in four cases it was performed some time after the patient had undergone previous abdominal surgery.

It is of interest to compare the precipitating surgical procedures in the "early" group with those of the "late" group. Of the "early" cases of postoperative obstruction, the primary procedure was a colon operation in five (35.7%). Pelvic operations were followed by obstruction in 35.7% of the early group; appendectomy, in 21.4%, and gastrectomy, in 7.2%. In the "late" cases, the primary operation was pelvic in 45.8%, an appendectomy in 33.3%, an exploratory laparotomy in 8%, and colon, stomach, and gallbladder operations in 4% each. Thus, there seems to be an increased tendency for small-bowel obstruction to arise in the early postoperative period after colon surgery. Appendectomy and pelvic operations are followed by adhesive intestinal obstruction with increasing frequency, proportionate to the passage of time.

Duration of Symptoms.—Exclusive of the "early" cases, the average patient complained of obstructive symptoms for a period of 5.5 days prior to hospital admission. Forty per cent of patients had experienced symptoms for two days or less. In cases of obstruction found at operation to be strangulating, the average duration of symptoms was 3.5 days, i. e., 2 days less than that in simple obstructions.

Pain.—With the exclusion of one comatose patient for whom the history was unobtainable, 58 (93.5%) of 62 patients presented a history of abdominal pain. All patients with strangulating obstruction had pain, whereas 8% of those with simple obstruction complained of vomiting without pain. Only two patients (4%) of those with simple obstruction described their pain as severe, whereas 81% of patients with strangulation complained of intense pain. In 85% of patients with simple obstruction the pain was colicky, and in the remainder it was steady. In all cases of strangulating obstruction the pain was crampy. Thus, our findings are not in agreement with the dictum that strangulation is most frequently accompanied by constant pain. In both groups the pain was located in the middle, lower, or right lower abdomen. In two patients (20%) with strangulating obstruction there was radiation of the pain to the back.

Vomiting.—Vomiting was a major complaint in 57 cases (90.5%). The vomitus was usually yellowish-green, yellowish-brown, or dark brown. In patients who had experienced pain, as well as vomiting, the latter began concomitantly with the pain. In 10 instances (20.5%), vomiting had its onset at some interval after pain began; in only 2 patients (4.1%) did vomiting precede pain in time of onset. With regard to vomiting, there was no difference between those with and those without strangulation.

Bowel Habits.—Two-thirds of the patients had not had a bowel movement for an average of three days prior to admission. On the contrary, one of three patients stated that bowel habits had been normal during the present illness.

Distention.—Abdominal distention of some degree was noted in 48 (76.2%) of the 63 patients. There was no appreciable difference in the proportion of patients with distention between those with simple and those with strangulating obstructions. However, 93% of those with early postoperative obstruction had distention, and in the ma-

jority of instances the degree of distention was marked. Of those with "late" obstruction, 72% had distention, and, in most cases, the degree was slight to moderate. These findings suggest that higher degrees of obstruction are more prevalent when the complication arises in the immediate postoperative period.

Tenderness.—Abdominal tenderness was a clinical finding in 74% of the entire group. All of the patients with strangulating obstruction experienced "marked" or "severe" abdominal tenderness. In the "late" group, 79% demonstrated abdominal tenderness, which was generally mild and diffuse. Six patients with early obstructions (43%) had mild tenderness, while eight were without tenderness. Thus, the presence of abdominal tenderness does not militate against the diagnosis of simple obstruction; in the presence of strangulation, however, the tenderness is more likely to be severe and localized.

Palpable Mass.—Palpable masses were reported in four cases (6.3%). In two of the cases with strangulating obstruction masses were demonstrated, one on rectal and one on abdominal palpation. Masses were palpable in two cases (14.3%) of "early" obstruction; both masses were intra-abdominal abscesses, and both were palpable rectally.

Temperature and Pulse.—Cases of "early" postoperative obstruction were eliminated from the study of temperature and pulse because of possible elevations resulting from recent tissue trauma, operative manipulation, and anesthesia. The average temperature in the presence of simple obstruction was 99.2 F, as compared with an average of 100.2 F in cases with strangulated bowel. In the one case of the series in which strangulation apparently developed after admission, the patient's temperature and pulse on admission were 98.6 F and 68 per minute, respectively; on the following day, along with the change in the clinical picture, the temperature rose to 101 F and the pulse rate to 110 per minute. In cases of strangulating obstruction, a progressive rise in temperature and pulse rate was observed generally; this phenomenon was not present in cases of simple obstruction.

Leukocyte Count.—When cases of "early" obstruction are eliminated, the average leukocyte count in cases of simple obstruction was 10,600 per cubic millimeter, with 75% neutrophils. However, in this group, 32% had counts higher than 12,000. In strangulating obstructions, the average leukocyte count was 13,950, with 80% neutrophils and a high proportion of immature forms. The relative increase in leukocytosis in the presence of strangulation is suggestive; nevertheless, hemoconcentration resulting from vomiting may account for some of the apparent increases in the leukocyte count.

Mortality.—Among the 63 patients studied, there were 5 deaths, an absolute mortality rate of 7.9%.

Case 1.—One death was that of a 78-year-old man who had undergone abdominoperineal resection for carcinoma of the rectum. One week postoperatively, he developed an acute anterior myocardial infarction. A mechanical small-intestine obstruction was noted 17 days postoperatively; this was successfully treated by means of passage of a Cantor tube into the small intestine. On the 21st postoperative day, the patient developed congestive failure and died suddenly.

Case 2.—A 57-year-old man, who had undergone sigmoid resection for recurrent volvulus, developed cardiac failure and right lobar pneumonia in the immediate postoperative period. Digitalization was accomplished. On the third postoperative day a mechanical small-bowel obstruction was noted. After three days of unsuccessful attempts to pass a Miller-Abbott tube, it was decided to perform a tube cecostomy. During the anesthetic induction, the patient went into cardiac arrest and died.

Case 3.—A 62-year-old woman underwent exploration for possible strangulating small-bowel obstruction. At operation, the ileum was found to be bound down to the right paracolic gutter by many adhesions, resulting from a cholecystectomy performed six years previously. About 18 cm. of ileum, damaged in the course of the difficult dissection, was resected, with primary ileoileostomy. Cardiac arrest occurred during the operation; normal heart rhythm was restored after two minutes of cardiac massage. The patient died four days postoperatively, probably as a result of the cerebral complications of cardiac arrest.

Case 4.—An 81-year-old man was brought to the hospital in a semicomatose condition with a history of a "stomach operation" three years pre-

viously, two weeks of vomiting, and complete obstipation for five days. At operation, a segment of gangrenous strangulated small bowel was resected, followed by primary anastomosis. Although the obstruction was relieved and the patient was having normal bowel movements, he developed progressive inanition and died in the hospital four weeks after operation.

CASE 5.—A 76-year-old woman who had undergone sigmoid resection for diverticulitis developed small-bowel obstruction 13 days after operation. After 24 hours of unsuccessful attempts to pass a Miller-Abbott tube, exploratory laparotomy was performed, and the ileum was found to be adherent to the sigmoid anastomosis. The adhesions were lysed. The patient died 24 hours after operation.

Eliminating the case of congestive failure following myocardial infarction and the two cases of cardiac arrest as not being direct complications of the obstruction, the *corrected* mortality rate is found to be 3.2%.

Treatment

Intubation Only.—Twenty cases (31.7%) were managed by intestinal intubation alone, with two deaths, a mortality rate of 10%. In 7 of the 20 cases, the obstruction arose in the early postoperative period, and it was in this group that both deaths occurred. Therefore, use of intestinal intubation as the sole means of therapy in the management of early postoperative mechanical obstruction resulted in a 28.6% mortality rate.

Passage of the long tube into the duodenum and small intestine was accomplished in periods varying from 3 to 72 hours. In one patient with marked dilatation of the small intestine and collapsed colon, attempts to pass a Miller-Abbott tube were unsuccessful over a four-day period. However, a Levin tube in the stomach on continuous suction, together with frequent colonic irrigations, resulted in complete decompression. In a similar case, two days of Levin-tube gastric suction achieved decompression, after unsuccessful attempts to pass the long tube.

After intubation, continuous suction was maintained for periods of 1 to 18 days, until it was felt that complete and lasting decompression was accomplished. The average period of intubation was six days.

Intubation Followed by Operation.—In 28 cases (44.4%) the obstruction was managed by intubation, followed by laparotomy and lysis of adhesions. There were three deaths (11.1%) in this group. In 11 instances operation was performed because of persistence of symptoms and signs of obstruction, along with unsuccessful attempts at passage of the long tube beyond the pylorus. There were two deaths in this group. Nine cases were successfully managed surgically after failure of attempts to pass the long tube during periods of one to four days.

In 16 cases laparotomy was performed because of persistence of clinical signs of obstruction, in spite of the presence of the tube in the small intestine, or because clamping of the tube resulted in recurrent symptoms. There was one death in this group.

Operation Only.—Fifteen patients (23.9%) were treated with early operation without previous attempts at intubation. There were no deaths in this group. In 13 cases suspected strangulation constituted the indication for early surgical intervention. In six of the latter patients (46.1%) strangulation of some degree was observed at operation. In only two cases did viability fail to return after release of the involved adhesion; in each of these instances resection of the involved bowel and primary anastomosis were carried out successfully.

Special Categories.—Strangulation: Twelve patients (19%) were found to have strangulated intestine at operation. The preoperative diagnosis was correct in 46.1% of cases. There were no false-negative diagnoses. In three patients clinical signs of strangulation developed after successful intubation of patients while under observation; recognition of the condition led to immediate successful operation in each case. The one death in the series of cases of strangulating obstruction occurred in the 81-year-old man who was brought into the hospital in an almost comatose condition. Six intestinal resections were performed, with one death, a 16.7% mortality rate.

"Early" Obstruction: Of the 14 cases of obstruction in the "early" postoperative period, 7 were managed with intubation alone, with two deaths (28.6%); 5 with intubation followed by operation, with one death (20%), and 2 with operation alone, with no death.

Operative Findings

The ileum was stated to be the site of obstruction in 32 (74.4%) of the 43 operative reports; the jejunum was implicated in 4 cases. In six instances the surgeon designated the "small intestine" as the obstructive site. In one case the sigmoid colon was obstructed by a fibrous band, around which the colon had twisted.

In cases in which the ileum was involved, the point of obstruction was usually in the midileum at least 10 cm. proximal to the ileocecal valve. When the primary operation was a gynecological one, the ileum was generally adherent to some area of the pelvic wall. In several cases in which ileal obstruction followed a gynecological procedure, the site of adhesion was one of the remaining pelvic viscera, e. g., cervical stump, broad ligament, or Fallopian tube. When the primary procedure was an abdominoperineal resection, the ileum was generally adherent to the region of the sacral promontory. In obstructions following an appendectomy or drainage of an appendiceal abscess, the ileum was frequently bound to the abdominal-wall scar. In a few instances the bowel was trapped and kinked by a fibrous band extending from the greater omentum to the small-bowel mesentery.

The ileum was the site of involvement in each of the 12 instances of strangulating obstruction. In five of these cases there was *torsion* of the ileum around an adhesive band, in contrast to simple obstruction, in which there was *kinking* rather than torsion. In three additional cases an adhesive band was found tightly encircling the bowel. In seven of the operative reports the surgeon noted the presence of free serosanguineous fluid in the peritoneal cavity.

Of the four cases of jejunal obstruction, two followed gastric resections, one resulted from adhesions at the site of a previous splenectomy, and in the fourth there was adherence to the scar of a previous appendectomy.

Comment

Acute intestinal obstruction resulting from postoperative adhesions occurs oftener in women than in men. This is explained by the marked frequency with which pelvic gynecological operations are followed by this complication. Obstruction may have its onset many years after the primary operation, which may account for the fact that, on the average, women are 10 years older than men at the time of onset of intestinal obstruction. When a second abdominal procedure follows the original pelvic operation after an interval of years, the tendency toward development of obstruction is markedly increased.

In cases of mechanical intestinal obstruction arising during the immediate postoperative period, symptoms are usually noted within a week following the primary operation. Colon operations are particularly likely to be complicated by early postoperative small-intestine obstruction due to adhesions.

Abdominal pain is likely to be severer and better localized in strangulating obstruction; in the majority of cases the character of the pain is colicky in both strangulating and simple obstructions. Vomiting usually begins with the onset of pain, rarely before. Distention is most marked in cases of obstruction arising in the early postoperative period; it is rarely a major sign in late cases of obstruction. Abdominal tenderness is commonest and severest in cases with strangulation; it is rarely marked in simple obstruction.

There is a high mortality rate (28.6%) when intestinal intubation is used as the sole form of therapy in cases of early postoperative mechanical obstruction. Because of the higher degrees of obstruction and lowered resistance of the patients, it seems reason-

able to advise early laparotomy in such cases.

In deciding for intubation or early operation, emphasis should be placed on the clinical and radiologic progress of the patient. Are colic and vomiting diminishing? Is distention subsiding clinically and radiographically? This implies repeated appraisal of the patient by physical and roentgenographic examination. Although the most satisfactory results occur when operation follows successful decompression by intestinal intubation, even unsuccessful attempts at intubation over periods as long as four days may be followed by effective surgery if the patient's clinical condition has not deteriorated. This is definitely not to say that we advocate a delay of 4 days before deciding for surgery, but we do feel that in most cases there is considerably more than a 12-hour leeway in which to attempt long-tube decompression, to replace electrolytes, and, in general, to prepare the patient for elective surgery.

On the other hand, in this series, early laparotomy proved to be much safer than had been our former impression, 15 patients having been treated thus without a death. Early operation is indicated when strangulation is suspected. It is the treatment of choice in the majority of cases of acute mechanical intestinal obstruction arising in the immediate postoperative period. Operation should be followed by intestinal intubation to prevent postoperative paralytic ileus.

The presence of strangulated bowel can be suspected in almost all cases by clinical signs and symptoms. Peritoneal tap for serosanguineous fluid is a valuable diagnostic procedure in the majority of cases. One should be wary of the development of the clinical features of strangulation occurring after successful intubation and decompression. In most instances of strangulation, viability returns after lysis of the offending adhesions.

As a result of this study, it is our impression that the incidence of intestinal obstruction due to postoperative adhesions would be reduced materially if greater care in reperitonealizing raw surfaces were employed. We are aware of recent arguments against the importance of reperitonealization; nevertheless, the high incidence of bowel adherence to areas denuded of peritoneum or areas in which separation of perhaps insecurely approximated peritoneal surfaces occurred leads us to favor careful reperitonealization wherever possible, especially in the vicinity of the pelvis.

Conclusions

1. Acute mechanical small-intestinal obstruction is particularly likely to occur as an early complication of colon surgery and as a late complication of pelvic gynecological operations.

2. Clinical evidences of strangulation are well marked in most cases. When a high index of suspicion is maintained, approximately half the patients subjected to early operation will prove to have no evidence of strangulation; nor will cases of early strangulation be missed.

3. All patients with findings suggestive of strangulating obstruction should undergo early laparotomy.

4. All patients in whom mechanical intestinal obstruction occurs as a complication during the postoperative hospitalization for an abdominal or pelvic operation should be considered candidates for early or immediate laparotomy.

5. The remaining patients should receive a trial of intestinal intubation and suction. Conservative treatment is continued if no signs or symptoms of strangulation develop, and if clinical improvement is progressive.

6. Operative findings suggest that adhesive bands which have precipitated intestinal obstruction are usually situated in an area which had been inadequately reperitonealized during a previous operation. It is our belief that careful reperitonealization wherever possible, especially in pelvic surgery, will do much to eliminate acute intestinal obstruction secondary to postoperative adhesions.

521 Park Ave. (21).

Wound Healing

I. Comparison of Heat- and Irradiation-Sterilized Surgical Sutures

RAYMOND W. POSTLETHWAIT, M.D.; JAMES F. SCHAUBLE, M.D.; MARCUS L. DILLON, M.D., and JOSEPH FREEMAN, M.D., Durham, N. C.

For many years, nonboilable collagen sutures have been sterilized by cumolization. In this process, heat sterilization is obtained at a minimum temperature of 155 C for a minimum period of one hour by placing the suture in a high-boiling hydrocarbon mixture. Tubing fluid is then added aseptically and the container sealed. A safer and cheaper method would be one in which sterilization is carried out in the final sealed container. This can be done by electron irradiation.

Studies [1] have been made with over 100 species of micro-organisms, including bacterial spores and fungi, to determine the minimum lethal dose of electron irradiation. Three million rep was selected as the irradiation dose, as this gave a safety factor of about 50%, which is in contrast to a safety factor of approximately 5% with heat-sterilization methods. Narat, Cangelosi, and Belmonte [2] have reported that irradiated sutures lose less initial tensile strength than those sterilized by heat. In a small series of animals, they found that tissue reaction to implanted sutures showed no substantial difference, handling properties were the same, and wounds healed equally well.

The present study was designed to compare wound healing, tissue reaction, and tensile strength of implanted sutures sterilized by irradiation and those sterilized by heat.

Submitted for publication Dec. 30, 1958.

From the Department of Surgery, the Veterans Administration Hospital, and Duke University Medical Center.

Supported in part by a grant from Ethicon, Inc., and by Grant No. RG-4656 from the Division of Research Grants and Fellowships, National Institutes of Health, U. S. Public Health Service.

Method

Young New Zealand rabbits were used. Operations were performed with aseptic technique. A long right rectus incision was made and closed with the suture under study. Interrupted sutures were placed through the anterior sheath, rectus muscle, posterior sheath, and peritoneum at 0.7-1.0 cm. intervals, grasping 0.3-0.5 cm. of tissue on each side. Surgeons' knots were carefully tied to approximate the wound edges. In the left rectus muscle, long loops of the suture were implanted longitudinally and tied very loosely to avoid tension. The following sutures were compared: 00 chromic catgut, 0000 chromic catgut, 00 plain catgut, 00 silk, and 0000 silk.

The animals were anesthetized 2, 4, 7, 14, 28, or 42 days after operation. Animals which showed any infection were discarded. The right rectus wound was cut transversely into strips 2 cm. wide. From one to three strips were tested for tensile strength, utilizing a simple suspension system in which water was gradually added to a container attached to the lower edge of the strip. Other portions of the wound and a section of tissue taken transversely from the left rectus across the implanted loops were fixed for histologic study. The loops of suture were then carefully removed from

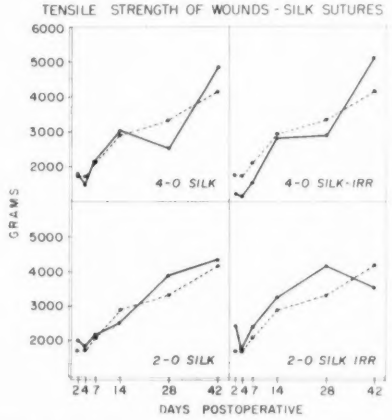


Fig. 1.—Tensile strength of wounds using silk sutures. The dotted lines are the means of 1,156 determinations.

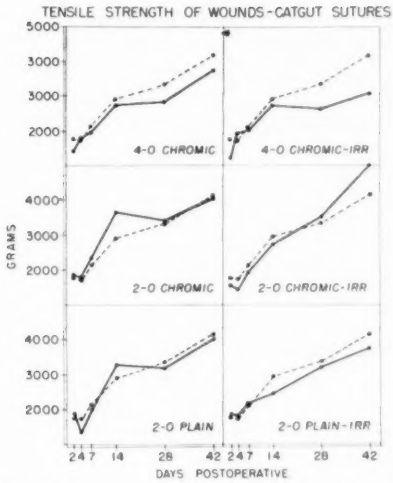


Fig. 2.—Tensile strength of wounds using catgut sutures.

the left rectus muscle and their tensile strength determined.

Tissue sections were stained with hematoxylin and eosin. Tissue reactions to the sutures were graded by the method of Sewell, Wiland, and Craver,[8] which is based on the type and degree of inflammatory response. A total of 227 animals were studied, which provided 677 determinations of wound tensile strength, 215 sections of wounds for grading, 515 determinations of suture tensile strength, and 838 sutures for histologic grading.

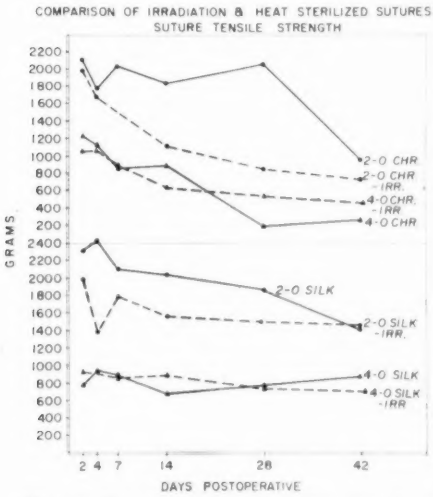


Fig. 3.—Comparison of the tensile strengths of the implanted suture showing the changes at intervals up to six weeks.

Results

The tensile-strength determinations of the wounds are shown in Figures 1 and 2, plotted in each instance against a curve obtained from a total group of 1,156 such tests obtained in this and similar studies. The tensile-strength patterns in all groups were very similar, and the variations were minor.

A system of grading of the wounds was established, based on the inflammatory reaction, the fibroblastic proliferation, and the formation of mature fibrous tissue. Utilizing this system, no differences could be demonstrated between the wounds sutured with the heat-sterilized sutures and the wounds closed with the irradiated sutures. The wounds followed the usual pattern of an early inflammatory response, then the rapid invasion of fibroblasts, and, finally, the formation of collagen.

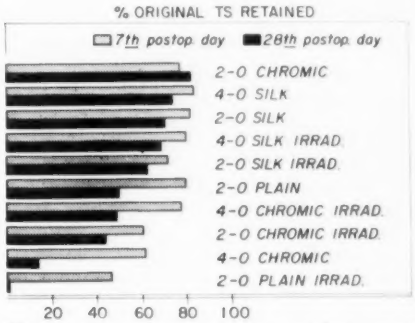


Fig. 4.—Percentage of the original tensile strength of each suture retained at 7 and 28 postoperative days.

The tensile-strength tests of the sutures are shown in Figure 3. On statistical analysis, a significant difference was found in the tensile strength of the 00 chromic catgut sutures which had been implanted for 7, 14, and 28 days. The difference in the 0000 chromic catgut suture was statistically significant only at 42 days. The 00 silk tensile-strength determinations differed significantly at 2, 14, and 42 days. The stronger sutures were those sterilized by heat in the 00 size, whereas this was considerably less obvious with the 0000 sutures.

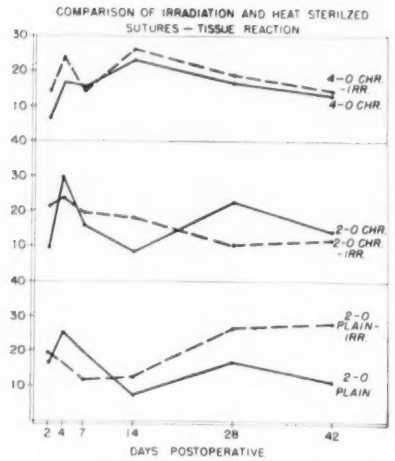


Fig. 5.—Grading of the tissue reaction to the catgut sutures.

Figure 4 shows the percentages of the original stensile strength which were retained on the 7th and 28th days after implantation of the suture loop. The bars have been arranged in decreasing strength retained on the 28th day. Nearly all of the sutures retain more than 70% of the original tensile strength on the seventh postoperative day. The catgut, with the exception of the 00 chromic, had lost considerable tensile strength by the 28th day, the 00 plain irradiated suture having so little tensile strength that an intact loop could not be removed for testing.

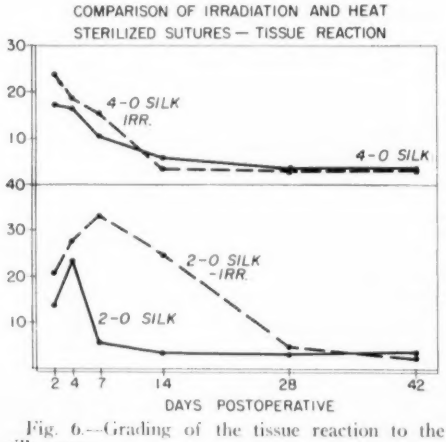

COMPARISON OF IRRADIATION AND HEAT STERILIZED SUTURES — TISSUE REACTION
4-0 SILK IRR.
4-0 SILK
2-0 SILK -IRR.
2-0 SILK
2 4 7 14 28 42
DAYS POSTOPERATIVE

Fig. 6.—Grading of the tissue reaction to the silk sutures.

Comparison of the grading of the tissue reactions to the suture is shown in Figures 5 and 6. The catgut sutures showed very little difference, with the exception of the plain catgut. The larger irradiated silk suture showed more reaction than the heat-sterilized suture at 7 and 14 days, but there was no difference at two later periods. In general, the earlier reaction to all of the sutures consisted first of edema, red cells, and fibrin about the suture, followed by the infiltration of a variable number of inflammatory cells. These were rapidly replaced by monocytes and fibroblasts, which matured usually by the 7th and uniformly by the 14th day. The catgut sutures differed from the nonabsorbable sutures because of the inflammatory reaction, which began at the time of the first absorption. This was very variable, as some sutures remained well encapsulated, whereas others of the same type, and even in the same animal, might show considerable absorption and the accompanying inflammatory-cell infiltrate.

Diameter and Initial Tensile Strength of the Sutures

Suture	Diameter, Ave., Mm.	Tensile Strength, Gm. Range	Tensile Strength, Gm. Average
2-0 chromic gut	0.3995	4,618-2,864	3,859
2-0 chromic gut, irrad.	0.3925	4,354-3,209	3,654
4-0 chromic gut	0.2336	1,600-1,009	1,400
4-0 chromic gut, irrad.	0.2379	1,795-1,077	1,432
4-0 plain gut	0.2397	1,341-713	1,145
4-0 plain gut, irrad.	0.2416	1,564-909	1,318
4-0 silk	0.2884	1,254-964	1,109
4-0 silk, irrad.	0.2385	1,250-1,118	1,218

In the accompanying Table are shown the results of the studies of a special group of sutures.* In the original studies the irradiated sutures and the heat-sterilized sutures were obtained from the manufacturer as they became available, whereas those used in this particular study were precisely the same in the manufacturing process, with the exception of the method of sterilization.

* These studies were performed by Mr. James A. King, at the Textile Research Laboratory, North Carolina State College, Raleigh, N. C.

The diameter of 10 samples of each suture was determined microscopically, and the tensile strength of 15 samples was obtained by the use of an Instrom tensiometer, which produces extremely accurate results. From the Table, it will be seen that the heat sterilization of 0000 silk resulted in a suture of slightly larger diameter than the irradiated suture. With the exception of the 00 chromic catgut, the irradiated sutures were all stronger in initial tensile strength than the heat-sterilized sutures, but the differences were not great.

Summary

A comparison has been made of the following sutures: 00 chromic, 00 plain, 00 silk, 0000 chromic, and 0000 silk with reference to sterilization by heat and by irradiation. The tensile strength of the wounds sutured with these materials showed very little variation, and a grading of the wounds showed no essential differences. The original tensile strength of the sutures appeared to be slightly greater in the group sterilized by irradiation. After implantation in the tissues, the loss in tensile strength showed no difference in the 0000 sutures but was somewhat greater in the 00 sizes for the irradiated sutures. No decided variation was noted by grading the reaction in the tissue to the suture. The handling properties were not affected. It is concluded that no adverse effects would be demonstrated which could be attributed to the irradiation sterilization process.

Veterans Administration Hospital, Fulton St. & Erwin Rd.

REFERENCES

1. Van Winkle, W. W.: Personal communication to the authors.

2. Narat, J. K.; Cangelosi, J. P., and Belmonte, J. V.: Electron Sterilization of Catgut, Surgery 41:324-327 (Feb.) 1957.

3. Sewell, W. R.; Wiland, J., and Craver, B. N.: A New Method of Comparing Sutures of Ovine Catgut with Sutures of Bovine Catgut in 3 Species, Surg. Gynec. & Obst. 100:483-494 (April) 1955.

Use of Suction in Control of Residual, Infected, or Draining Cavities, Tracts, and Fistulas

CAPT. KERMIT Q. VANDENBOS (MC), U. S. A. F.; LT. COL. CARL W. HUGHES (MC), and COL. WARNER F. BOWERS (MC), U. S. Army

Mechanical principles and basic elements of wound healing too often are neglected, attempts being made to substitute antibiotic administration for application of fundamentals of surgery. Young physicians are prone to order antibiotics for any patient who has a residual or infected cavity or a draining sinus tract, neglecting the important aspects of proper wound care. Almost any wound will heal and most cavities or tracts will close, provided that they are kept clean and dry and provided, further, that there is no retained foreign body, neoplastic tissue, or specific granulomatous infection. In an attempt to emphasize the importance of wound care, a widely diverse group of patients has been treated by continuous catheter suction and periodic saline irrigation, entirely omitting antibiotic administration. Results have been so striking that this report seems warranted.

To ensure wound healing, dead space must be obliterated, and the wound must be kept continuously free of collections of serum, blood, tissue fluid, liquefied fat, or purulent exudate. If there is injury of an organ that secretes or transports fluids, these also must be removed from the wound continually. Accumulations of fluid in the peritoneal cavity from anastomotic leaks can be controlled by constant suction, and these leaks can be allowed to heal without fear of generalized peritonitis or fistulization. All of these problems are mechanical matters, rather than an exercise in surgical bacteriology, so that antibiotics play no necessary part in management.

Submitted for publication Nov. 3, 1958.

From the Department of Surgery and General Surgery Service, Tripler Army Hospital.

Thoracic surgeons commonly use suction applied through a catheter to obliterate dead space and remove accumulations of fluid in the chest. The general surgeon also can use this technique to control residual, infected, or draining cavities and tracts in place of bulky pressure dressings, which are uncomfortable, tend to slip, and necessitate frequent painful dressing changes for the patient. Rubber dam or Penrose drains too frequently fail to perform their function adequately, being dependent upon intrinsic or extrinsic wound pressure and gravity.

The technique of obliteration of dead space and attainment of adequate wound drainage by using properly placed catheters in a wound for application of suction is not new. Wangensteen,[5] in 1949, suggested the use of catheter suction under the left diaphragm after a total gastrectomy to remove the postoperative collections of fluid. Raffl,[3] in 1952, used catheter suction under the skin flaps after a radical mastectomy, and Lattimore,[2] in 1954, used catheter suction in the subcutaneous abdominal wound after ventral hernia repair. Like other authors [1-4] who have reported recently in the literature, we have used catheter suction under the skin flaps of radical neck dissection, radical mastectomy, and axillary and groin dissections; after ventral hernia repair, and in perineal wounds after abdominoperineal resection. Some authors have advocated the use of catheter suction also in amputation stumps.

In general, before the skin closure is accomplished, a No. 20 F., firm rubber catheter with multiple perforations in the distal one-fourth is placed in the most dependent

portion of the wound, away from any large vessels, nerves, or anastomotic suture lines. The catheter is brought out through the skin through a separate tiny incision, and skin closure is made snug, so that, when suction is applied to the catheter, a vacuum is created under the skin flaps, causing the flaps to adhere to the underlying structures. Approximately 5 lb. of suction is applied with a Stedman pump, Gomco suction, or Wangensteen suction apparatus across a bottle trap that collects the drainage. The catheters are left in place from three to five days, a comfortable small dressing being applied over the wound. The amount of daily collected drainage varies, but, in general, from 100 to 200 cc. of fluid is collected from beneath the skin flaps on the first postoperative day and 50 cc. or less on the second day; thereafter usually little drainage occurs, except in cases of anastomotic fistula.

Report of Cases

The following illustrative cases represent some of the instances in which we have used catheter suction.

CASE 1.—A 39-year-old white man with a controlled carcinoma of the nasopharynx developed a metastatic mass in the right side of the neck one and one-half years after x-ray therapy to the nasopharynx and neck. A right radical neck dissection was done through an incision from the chin to the angle of the mandible and thence down to the clavicle along the sternocleidomastoid muscle. The many new vessels from x-ray therapy made hemostasis more difficult than usual, and a catheter was placed in the wound beneath the skin flap for application of continuous suction. In the first 24 hours 230 cc. of fluid was collected, 100 cc. in the second 24 hours, 60 cc. during the third day, and none thereafter, until the catheter was removed in another 48 hours. A comfortable dressing was used, as is shown in the accompanying Figure.

CASE 2.—A 51-year-old white woman had abdominoperineal resection for adenocarcinoma of the rectosigmoid, with primary closure of the perineal wound about a suction catheter. Three hundred cubic centimeters of fluid was removed in the first 24 hours, 50 cc. on the second day, and none thereafter, until removal of the catheter on the fifth postoperative day. The perineal wound healed primarily.

Catheter suction is being applied after right radical neck dissection. The Stedman pump and bottle fluid are shown. Photography Acc. No. Tr11112, Tripler Army Hospital.

CASE 3.—In a 65-year-old, obese white man an incisional hernia developed one year after cholecystectomy through a subcostal incision. Repair was done one year later, and, because of extensive dissection, a suction catheter was placed in the subcutaneous cavity. In the first 24 hours, 175 cc. of serosanguineous fluid was collected, 60 cc. in the second 24 hours, 40 cc. on the third day, and none thereafter, until the catheter was removed on the sixth postoperative day. The wound healed primarily without complications.

CASE 4.—A 61-year-old man had resection of the cardiac portion of the stomach for Hodgkin's disease. A primary esophagogastrostomy was done below the diaphragm. Penrose drains were placed near the anastomotic line. On the third postoperative day the patient had emesis about the nasogastric tube, followed by profuse drainage of bile-stained gastric secretions via the Penrose drains. In spite of continued nasogastric suction, the abdominal dressings had to be changed hourly. Roentgenograms revealed a leakage at the suture line. A No. 12 F. catheter was inserted alongside the Penrose drains to a point beneath the diaphragm and connected to suction. From 1,000 to 2,000 cc. of fluid was collected daily for two days. The drainage subsided in five days, at which time the leakage site had sealed and the catheter then was removed. Adequate drainage of the anastomotic leak prevented peritonitis or local abscess formation and allowed healing without stricture formation, although no antibiotics were used.

CASE 5.—A 26-year-old man was stabbed in the right upper quadrant of the abdomen. At laparotomy an anterior laceration of the duodenum was repaired. Penrose drains were placed near the operative site. The nasogastric tube was removed on the third postoperative day, and a profuse drainage of bile and intestinal juices occurred about

the Penrose drains, in spite of reinstitution of the nasogastric suction tube. A catheter was passed alongside the Penrose drains, and with suction there was collected 3,000 to 4,000 cc. of fluid each day for seven days, after which time the drainage gradually decreased. Oral feedings were started on the 12th postoperative day, and the catheter was removed on the 15th postoperative day.

A posterior laceration of the duodenum was unrecognized at laparotomy. Catheter suction collected the wound drainage adequately, and the patient recovered without additional operations or complications. No antibiotics were used.

Case 6.—A 46-year-old white man with a chronic duodenal ulcer began having symptoms of obstruction. At the time of subtotal gastrectomy, the duodenum was found to be excessively scarred and adherent to all surrounding tissues, including the pancreas. Closure of the duodenal stump was accomplished, but the closure was insecure. For this reason, a suction catheter was placed alongside the duodenum. On the sixth postoperative day the patient developed a fullness in the right upper quadrant of the abdomen. Suction on the catheter was instituted, and copious amounts of bile-stained intestinal juices were withdrawn from the abdomen daily. It was apparent that the patient had a duodenal fistula. The catheter suction was continued, and the drainage gradually subsided over a period of 14 days, at the end of which the duodenal fistula healed without antibiotics and without surgical closure of the fistula.

Case 7.—A 20-year-old youth suffered a ruptured kidney in an automobile accident. Nephrectomy was done, and Penrose drains were placed at the operative site. Postoperatively, the patient had drainage of pancreatic juices about the Penrose drains, causing severe skin irritation. Catheter suction was instituted alongside the Penrose drains, and the pancreatic secretions were collected in the bottle trap until the drainage subsided.

After institution of catheter suction, no further skin irritation from the pancreatic secretions occurred. The pancreatic fistula gradually subsided over a period of two weeks, and the wound healed without additional complication. No antibiotics were used.

Case 8.—A 34-year-old white man had removal of a calcified cystic mass of the right flank. The mass was a residual of an old perinephric hematoma. Postoperatively, the patient had drainage of urine alongside the Penrose drains that were placed in the operative site. The drainage was so profuse that the dressings had to be changed hourly. A catheter was inserted alongside the Penrose drains, and, with suction, 1,000 to 1,500 cc. of urine was collected daily. Only one change of dressings each day was then necessary. Nephrectomy eventually was carried out.

Case 9.—A 42-year-old white man was admitted to the hospital four days after an appendectomy elsewhere. The appendectomy wound was inflamed and fluctuant. The skin sutures were removed, and fluid feces poured from the wound. Catheter suction was applied to the wound, and by the 10th postoperative day the fecal fistula had spontaneously closed. In the interim, the fecal drainage was collected in the suction bottle, minimizing the amount of daily wound care. The abdominal wound subsequently healed without additional complications.

Adequate drainage of the fecal fistula allowed prompt healing of the fistula, and the abdominal wound healed, with little discomfort to the patient.

Daily irrigations of the fistula tract with saline through the catheter kept the wound clean, and antibiotic treatment was not used.

Case 10.—A 36-year-old white man had fever, chills, tenderness of the liver on palpation, and a fixed right diaphragm as seen fluoroscopically. At laparotomy an amebic abscess of the liver was found, and through a trocar a catheter was placed in the abscess cavity. The catheter was brought out through a small flank incision and connected to suction. Specific antiamebic therapy was instituted. After 10 days of catheter suction, the cavity by roentgenogram was sufficiently reduced in size that the catheter could be removed. Daily irrigations of the cavity had kept it clean, allowing prompt healing.

Case 11.—A 28-year-old white man was operated on for appendicitis, and a large abscess cavity was encountered and drained, using Penrose drains. One week, and again four weeks, after operation, the patient had additional operations to drain additional abdominal abscess cavities. Penrose drains were used again. Eight weeks following the first procedure, the patient was admitted to Tripler U. S. Army Hospital. The patient had been on high doses of antibiotics and still had a draining lower abdominal cavity and sinus tract. Catheter suction was instituted, and from 100 to 200 cc. of purulent material was removed daily from the cavity. The cavity was repeatedly irrigated with saline. Antibiotics were discontinued. The drainage decreased, and the cavity gradually closed in two weeks. Observation for an additional two weeks preceded appendectomy. One week after appendectomy, a fluctuant mass was observed in the region of a previous abscess cavity. The overlying skin was incised, and air and feces escaped from the re-formed intra-abdominal abscess cavity. Catheter suction was reinstituted, and the cavity was irrigated with saline daily. In two weeks the cavity was obliterated and the fecal fistula subsequently closed, and the wound healed without the use of antibiotics. This patient has been followed for nearly one year and has had no recurrence of his disease.

Removal of the source of infection with adequate drainage and cleansing of the intra-abdominal abscess cavity facilitated closure of the cavity and allowed wound healing without the use of antibiotics.

Summary

Cavities, tracts, and fistulas tend to close spontaneously if kept clean and dry, provided that there are no deterrents, such as foreign bodies, neoplastic tissue, or specific granulomatous infections.

Suction applied through a catheter in a wound, cavity, or tract with saline irrigation at intervals will keep such wounds clean and dry, so that uncomplicated healing follows quickly. These problems are not bacterial, and antibiotics are not used.

Continuous suction has been used under the skin flaps formed in such undermining procedures as radical mastectomy, radical neck dissection, axillary and inguinal dissections, in the subcutaneous area after incisional hernia repair, and in the perineum after abdominoperineal resection. Such wounds heal rapidly and well, only a small dressing being needed. No wound infections have eventuated from use of the catheters.

Continuous suction has been used in intra-abdominal abscess cavities and liver abscess cavities, with periodic saline irrigation to promote cleanliness. Such wounds have healed rapidly and well without antibiotics.

Continuous suction has been used in anastomotic leaks or fistulous tracts from esophagogastric junction, duodenal stump or injury site, pancreatic fistula, and fecal fistula. Rapid healing eventuated in each instance without abscess formation or other complication, without the need for surgical intervention or without the use of antibiotics.

Tripler Army Hospital, APO 438, San Francisco.

REFERENCES

1. Connolly, J. E.: Prevention of Postoperative Subcutaneous Fluid Collection by Suction, J. A. M. A. 157:1490-1491 (April) 1955.

2. Lattimore, T. J., and Koontz, A. R.: Suction Drainage After Implantation of Tantalum Gauze Sheets, J. A. M. A. 155:1333-1334 (Aug.) 1954.

3. Raffl, A. B.: The Use of Negative Pressure Under Skin Flaps After Radical Mastectomy, Ann. Surg. 136:1048 (Dec.) 1952.

4. Silvis, R. S.; Potter, L. E.; Robinson, D. W., and Hughes, W. F.: The Use of Continuous Suction Negative Pressure Instead of Pressure Dressing, Ann. Surg. 142:252-256 (Aug.) 1955.

5. Wangensteen, O. H.: Technical Suggestions in the Performance of Total Gastrectomy, Surgery 25:766-775 (May) 1949.

Gallstones and Pregnancy

ALFRED M. LARGE, M.D.; JAMES E. LOFSTROM, M.D., and CHARLES S. STEVENSON, M.D., Detroit

Although there is generally assumed to be a relationship between pregnancy and the formation of gallstones, available evidence is confusing and indicates little, if any, statistical support for such an opinion. Many years ago Schroeder [1] carefully investigated this problem. In the latter part of the 19th century he analyzed 1,150 autopsy cases and, on the basis of these studies, found that 90% of women with gallstones had had children. His figures, which were published in 1892, have been variously and widely quoted since that time as establishing a relationship between pregnancy and the formation of gallstones, although, curiously enough, Schroeder himself did not seem to be particularly impressed with this idea. During the 60-odd years that have elapsed since this work was reported, numerous studies of living patients with gallstones and of postmortem material have been published, with the majority of investigators favoring the idea that pregnancy is an etiologic factor in the development of stones. Several authors, however, including Hurst [2] and others, have been impressed with the idea that, even though most women with gallstones have been pregnant, the incidence of pregnancy in women with gallstones seems to be no greater than the over-all incidence of pregnancy among women, and therefore that no definite etiologic relationship exists between the two. Robertson and Dochat,[3] in 1944, exhaustively reviewed the literature on this subject and pointed out that gallstones are very uncommon in both sexes before the age of 20, that stones are commoner in women than in men, and that the increase in incidence after the age of 20 begins earlier in women than in men. They also analyzed their own cases of gallstones from the Mayo Clinic and confirmed the above figures, but found as well that, while about 80% of women with gallstones have had children, about 80% of the total population of women have had children at one time or another; they therefore concluded that these figures in themselves did not establish any relationship whatever between pregnancy and the formation of stones.

The entire question has remained undecided up to the present. It seemed to us that an actual survey of pregnant women might give further information as to this possible relationship.

Method

Three hundred fifty-two pregnant women, asymptomatic patients in the prenatal clinics at the Herman Kiefer and Detroit Receiving Hospitals, were interviewed, clinical histories obtained, and cholecystographic studies performed. When the results of the x-rays were equivocal, they were repeated whenever possible, particularly in those cases in which any suggestion of gallstones appeared. Postpartum x-ray studies were done on 55 of the women.

Results

The 352 pregnant women studied ranged in age from 13 to 43, and the number of previous pregnancies, from none to 13. Prenatal x-ray studies were done on only 55 white patients, thus indicating that most of the patients in this series were Negroes. The 352 patients represented a total experience of 1,104 pregnancies. The cholecysto-

Submitted for publication Oct. 27, 1958.

Supported by a grant from the Research Corporation of the Detroit Receiving Hospital and the National Institutes of Health, A-659 and A-699.

From the Departments of Surgery, Radiology, and Obstetrics and Gynecology of Wayne State University College of Medicine, the City of Detroit Receiving Hospital, and the Herman Kiefer Hospital.

TABLE 1.—*Relation of Gallstones and Pregnancy*

Age Group of Patient	Patients			Pregnancies (Not First)		
	No.	No. with Stones	Per Cent with Stones	No.	No. with Stones	Per Cent with Stones
0-9	0			0		
10-19	98	0	0	86	0	0
20-29	210	9	4.3	667	9	1.3
30-39	41	2	4.9	221	2	0.9
40-49	3	0	0	24	0	0

grams were all normal, except in 11 instances. In seven of these the presence of gallstones was definitely shown on x-rays (the x-ray studies were repeated if necessary to confirm the diagnosis), whereas the gallbladder was not visualized in three cases, and in one the result was questionable. If the questionable case and the nonvisualizations are included with those in which stones were shown, the incidence would be the maximum possible; that is, 11 cases in the entire group of 352 cases, or 1,104 pregnancies. It should be noted that 102 pregnancies were first ones and that this experience therefore relates to 1,002 pregnancies who had had previous pregnancies. The incidence of stones for the various age groups is shown in Table 1; this Table also relates these findings to the number of patients and the number of previous pregnancies in each age group.

In this series, in which 55 of the patients had postpartum x-ray studies, there were 2 who had had normal cholecystograms early in pregnancy and who developed gallstones that were visualized on the x-rays following pregnancy. Their histories briefly follow.

CASE 1.—A 21-year-old Negro primipara had a normal cholecystogram on March 1, 1956. She delivered a full-term infant June 3, 1956, and was found on Oct. 24 to have a well-functioning gallbladder, containing numerous small stones.

CASE 2.—A 28-year-old Negro woman had previously delivered normal, full-term infants by cesarean section in 1951 and 1955. The x-rays of her gallbladder were normal on June 20, 1956; she was delivered of a normal full-term infant (again by cesarean section) on Oct. 11, 1956; and on Dec. 17, 1956, cholecystogram showed nonvisualization of the gallbladder. This patient could not again be located, and a repeat examination therefore was not possible.

Comment

This survey of an unselected group of normal pregnant women should give an accurate impression of the incidence of gallstones in the various age groups which they represent. Ideally, such figures should be compared with cholecystograms of women from similar age groups who have not been pregnant. Unfortunately, the latter figures are not available; however, a very large number of patients dying of causes other than gallstones have been studied at the Mayo Clinic and the incidence of gallstones reported, as shown in Table 2. This Table also compares the Mayo Clinic results with our own figures. It is obvious that the incidence of gallstones is considerably less in the pregnant women in our series than in the postmortem cases of all females, both pregnant and nonpregnant. This is true even when the ages of the two groups are carefully compared. Although it is questionable whether a group of patients dying of various causes can legitimately be compared with a series of healthy women without symptoms; yet, if this comparison is justified, there would seem to be grave doubt whether any

TABLE 2.—*Incidence of Gallstones in Pregnancy and General Postmortem Series*

Age Group of Patient	Gallstone Incidence in Postmortem Series, %*		Pregnancy Incidence, %†
	Male	Female	
0-9	0.1	2.0	--
10-19	0.3	0.7	0
20-29	2.4	6.0	4.3
30-39	6.3	12.4	4.9
40-49	9.7	22.3	--

* Robertson and Dochat[5] (Mayo Clinic).
† Our series.

relationship between pregnancy and the formation of stones really exists on the basis of these figures alone.

The present survey, although representing an experience with only 352 patients, does yield information on patients who have experienced over 1,000 pregnancies (102 of the 1,104 pregnancies were first pregnancies). It is our opinion that the total number of pregnancies reviewed is much more important statistically than the total number of cases. Therefore, if one relates the incidence of gallstones to the number of pregnancies, it becomes so low as to be hardly appreciable at all.

Sparkman[4] has reported recently a considerable incidence of gallstones in young women. This report is interesting but appears to us to be of little significance with respect to the relationship between pregnancy and gallstones, even though most of his patients with gallstones had been pregnant at one time or another. It seems to us that Sparkman's report confirms the belief that gallstones do occur in young women, particularly in those who have had children, but does not prove any direct etiologic relationship.

It is well known that the incidence of gallstones increases with age, both in men and in women, but particularly in women. It has been supposed by some that metabolic changes occurring in pregnancy will produce, or tend to produce, gallstones later in life. This to us is inconceivable. Any change in the chemical nature of bile which occurs during pregnancy must of necessity produce its effect during pregnancy, and not years later. If material is to be precipitated because the bile has been changed or the gallbladder is functioning in a different way, this material will be precipitated during the time that the change is in effect, and not later on in life. Thus, we see no need to assume that pregnancy has anything to do with the occurrence of gallstones as women grow older.

A number of years ago Potter[5] reported chemical studies of the bile drawn from the gallbladders of pregnant women at cesarean section. He concluded that the bile in the pregnant women differed appreciably from that found in the gallbladders of normal women. Unfortunately, methods of chemical analysis of bile at that time were rather inaccurate; and there now seems to be some doubt, as judged by present standards, that these determinations were correct. Studies by Johnston and associates are currently being conducted in our own laboratory[6] with the use of more modern and accurate analytical methods, on gallbladder bile both from pregnant women at the time of cesarean section and from nonpregnant women during operation for other conditions. These studies should throw further light on this controversial question and will be reported in the near future.

Summary

Analysis of the data from clinical and cholecystographic studies performed on 352 pregnant women (and repeated post partum on 55 of them), representing an experience of 1,104 pregnancies, failed to demonstrate any definite relationship between pregnancy and the formation of gallstones.

Dr. Charles G. Johnston, Profesor and Chairman of the Department of Surgery, Wayne State University College of Medicine, suggested this study and gave helpful advice and support throughout the project. Dr. C. Dale Barrett, Director of the Division of Maternal and Child Health, City of Detroit Department of Health, permitted and encouraged this study of the prenatal patients at Herman Kiefer Hospital.

Wayne State University, 1401 Rivard St. (7).

REFERENCES

1. Schroeder, H.: Beitrag zur Aetiologie und Statistik der Cholelithiasis, C. Göller, Strasbourg, 1892.

2. Hurst, A. F.: The Constitutional Factor in Disease, Brit. M. J. 1:823-827, 1927.

3. Robertson, H. E., and Dochat, G. R.: Pregnancy and Gallstones: Collective Review, Internat. Abst. Surg. 78:193-204, 1944, in Surg. Gynec. & Obst., March, 1944.

4. Sparkman, R. S.: Gallstones in Young Women, Ann. Surg. 145:813-824, 1957.

5. Potter, M. G.: Observations of the Gallbladder and Bile During Pregnancy at Term, J. A. M. A. 106:1070-1074, 1936.

6. Johnston, C. G., and others: Personal communication to the authors.

Case Reports

Successfully Resected Leiomyoma of Jejunum in a Newborn

ANDREW B. BREUDER, M.D.; ALVIN R. MINTZ, M.D.; HARALD J. SCHWARZ, M.D., and EARL D. STAGE, M.D., Morristown, N. J.

Leiomyomas of the small intestine in the adult are not common but are occasionally encountered. The literature has been reviewed by Golden and Stout [1]; Morton, Stabins, and Morton [2]; Starr and Dockerty [3]; Straus and O'Kane [4]; Cherry and Hill,[5] and Eckel.[6] Pennino and Abbene [7] have described a case of a leiomyosarcoma in a 7-month-old infant; they believe that the leiomyoma can become malignant. Roth and Farinacci [8] report a case of a leiomyosarcoma in a newborn infant.

As far as we know, this is the first case of a successfully resected leiomyoma of the jejunum in a newborn infant to be reported. Leiomyomas are benign tumors, and, according to Andersen,[9] most benign tumors in children are malformations. Yet one might wonder whether the hamartomatous leiomyoma is not a precursor of the malignant variety; such an assumption supports the congenital anlage theory (Cohnheim-Ribbert).

Report of Case

The infant, born at term to a 23-year-old mother, was the second child. The weight of this baby girl was 6 lb. 3 oz. (2,807 gm.). Approximately 12 hours after the uneventful delivery, the infant's abdomen became progressively distended, and she vomited several times. A flat plate of the abdomen revealed fluid levels in the dilated loops of the small bowel, and there was no evidence of gas in the colon. The findings suggested obstructive phenomena, interpreted either as a congenital band or as atresia of the small bowel.

Submitted for publication Nov. 11, 1958.

From the Departments of Surgery, Pediatrics, and Pathology, All Souls Hospital.

A laparotomy was performed approximately 25 hours after delivery. The area of obstruction was located at about the midjejunum and consisted of a rather firm tumor. The jejunum proximal to the obstruction was distended and measured approximately 3 cm. in diameter; the jejunum distal to the obstruction measured approximately 0.5 cm. in diameter. By injection of air the distal jejunum was dilated to approximately two or three times its diameter. The intestinal tract was found to be patent. The segment of jejunum with the tumor, including the mesentery, was resected. An incision was made in the antimesenteric border of the distal air-dilated jejunum, and the open end of the proximal jejunum was anastomosed in an end-to-side fashion. After the anastomosis the gas from the proximal jejunum diffused into the distal portion. The abdomen was closed in the usual fashion. Postoperatively, the temperature remained normal. Fluid and electrolyte balance was maintained with parenteral administration of fluids for the first six days. On the third day sterile water drinks, on the fourth day sterile water and 5% dextrose drinks, and on the fifth and sixth days a diluted Similac formula were given. Subsequent formula feedings caused some abdominal distention, which gradually disappeared. On the fourth postoperative day the patient developed mild jaundice, of short duration. On the 17th postoperative day the baby was discharged, without symptoms. Thereafter she developed normally, and now, approximately one and a half years after the operation, she is well and weighs 21 lb. (9,526 gm.).

*Pathologic Examination.**—The specimen consists of a portion of small intestine that measures 5.5 cm. in length and is comprised of two segments, measuring 3 and 0.5 cm. in diameter and 1.8 and 3.7 cm. in length, respectively. Section reveals a lumen that, at the junction of the two segments, is stenosed by a protruding globular intramural mass that measures 2 cm. in diameter. The cut

* The sections were examined by the Armed Forces Institute of Pathology (AFIP Acc. #887985).

Fig. 1.—Cross section of jejunum with intramural leiomyoma. × 4.5.

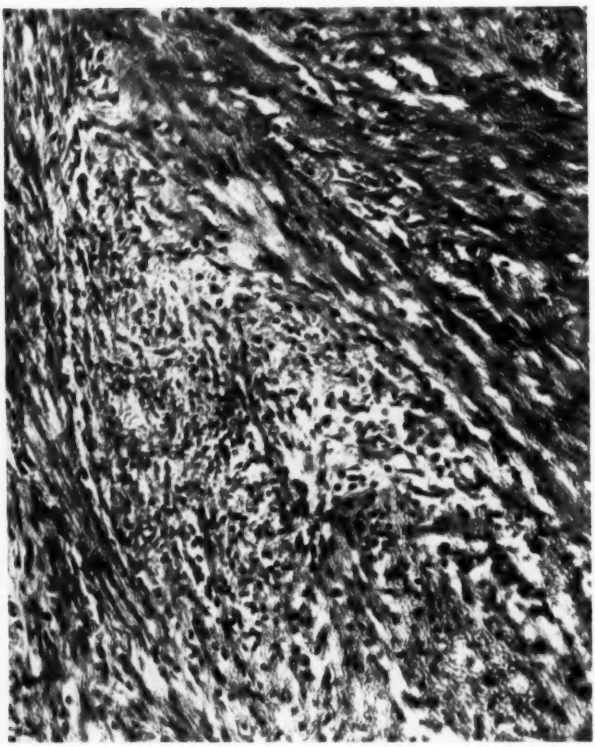


Fig. 2.—Smooth-muscle fibers forming leiomyoma. × 200.

surface of this mass is pale gray, firm, and somewhat laminated. The mucosal aspects of the jejunum reveal the usual circumferential folds.

Histologic examination reveals a cross section of the small intestinal tract (Fig. 1). The lumen is markedly compressed and stenosed by an intramural, poorly demarcated mass, which is comprised of elongated eosinophilic cells with elongated nuclei, having blunted edges (Fig. 2). There is proliferation of muscle-like cells; there are more or less mature-appearing fascicles of muscle tissue, and some of these represent a part of the normal musculature of the intestinal tract. In addition, within the mass there are a few gland-like structures, lined with a cuboidal or columnar epithelium. These glands have a certain resemblance to intestinal glands. A trichrome (Masson) stain reveals red-staining muscle bundles, surrounded by bands of blue-staining fibrous connective tissue. The diagnosis was leiomyoma of jejunum arising on the basis of a hamartoma.

Summary

A case of leiomyoma of the jejunum arising on the basis of a hamartoma in a newborn infant is described. This tumor has been successfully resected.

All Souls Hospital, 95 Mount Kemble Ave.

REFERENCES

1. Golden, T., and Stout, A. P.: Smooth Muscle Tumors of the Gastrointestinal Tract and Retroperitoneal Tissues, Surg. Gynec. & Obst. 73: 784, 1941.

2. Morton, J. H.; Stabins, S. J., and Morton, J. J., Jr.: Smooth Muscle Tumors of the Alimentary Canal, Ann. Surg. 144:487, 1956.

3. Starr, G. F., and Dockerty, M. B.: Leiomyomas and Leiomyosarcomas of the Small Intestine, Cancer 8:101, 1955.

4. Straus, F. H., and O'Kane, C. R.: Leiomyoma of the Duodenum: Case Report and Review of the Literature, Surgery 32:869, 1952.

5. Cherry, J. W., and Hill, R. L.: Leiomyoma of the Jejunum: A Neoplasm Imitating the Symptoms of Duodenal Ulcer, A. M. A. Arch. Surg. 62:580, 1951.

6. Eckel, J. H.: Primary Tumors of the Jejunum and Ileum, Surgery 23:467, 1948.

7. Pennino, J. V., and Abbene, M. M.: Intussusception in an Infant Due to Leiomyosarcoma of the Jejunum, Am. J. Surg. 93:461, 1957.

8. Roth, D., and Farinacci, C. J.: Jejunal Leiomyosarcoma in a Newborn, Cancer 3:1039, 1950.

9. Andersen, D. H.: Tumors of Infancy and Childhood: I. A Survey of Those Seen in the Pathology Laboratory of the Babies Hospital During the Years 1935-1950, Cancer 4:890, 1951.

Spontaneous Cholecystocholedochal Fistula

Two-Year Follow-Up of a Case

CHURCH E. MURDOCK JR., M.D., Mobile, Ala.

For various reasons, the true incidence of biliary lithiasis is unknown. Since spontaneous internal biliary fistulae are a statistical function of cholelithiasis, their incidence is likewise unknown. One author estimates the incidence of such fistulae at 3%, based on a broad personal experience. The validity of this estimate is strongly questioned in the light of a recent paper from the Lahey Clinic,[2] covering 29 years. Only 41 spontaneous internal biliary fistulae were treated in this period. This very low incidence is undoubtedly owing to more aggressive assault on the earlier phases of cholecystic disease in recent decades.

Of these 41 fistulae, 3 were cholecystocholedochal. The technique of establishing this diagnosis and the management thereafter were not touched upon. That a preoperative diagnosis will frequently be impossible is recognized.

From a practical standpoint, discussions with active surgeons with 15 and more years of experience have revealed the cholecystocholedochal fistula to be very unusual, even unknown. Personal experience indicates that the uncommon may prove enigmatic simply from lack of acquaintance. Therefore, it is felt reasonable to report a single experience with this entity.

The foregoing discussion considers aspects of etiology, incidence, etc. A brief word about pathogenesis may be in order. All surgeons have noted that acute distention of the gallbladder tends to place Hartmann's pouch anterior to and in apposition with the common bile duct. Fusion of these structures, with subsequent erosion by stone of the septum so formed, explains the mechanism of formation of the fistula.

Submitted for publication Dec. 15, 1958.

Report of Case

The patient was admitted to the surgical service of the University Hospital, Little Rock, Ark.* on Aug. 22, 1956, with the chief complaint of yellow jaundice, of one week's duration.

History of Present Illness.—The 74-year-old white man gave a history of anorexia and moderate weight loss during the preceding six to eight months. Vague upper abdominal pain had been present for four years. Five days prior to admission, sudden, severe pain developed in the epigastrium, which radiated laterally around the costal margin to the back and persisted for several hours. This pain was associated with nausea and vomiting. The patient received hypodermic injections from his local physician, was told he had yellow jaundice, and was referred to the University Hospital.

Physical Examination.—The patient appeared acutely and chronically ill. Blood pressure was 140/70; pulse 120 a minute. The sclerae were icteric. There were crepitant rales in both lung bases. Cardiac examination revealed a Grade 2 apical systolic murmur with a normal sinus rhythm and no clinical enlargement. Positive abdominal findings were marked abdominal distention with mild right upper quadrant tenderness and good bowel sounds. Rectal examination elicited clay-colored stools. The neurological examination was not remarkable.

Laboratory Data.—Hemoglobin 13.5 gm. %; white blood cells 27,000 per cubic millimeter. Urine positive for urobilinogen. Prothrombin time 62% of normal. Total serum proteins 6 gm. %; A/G ratio 1.6:1; NPN 29.5 mg. %; CO_2 40 mEq/L.; chlorides 88 mEq/L.; alkaline phosphatase 86 King-Armstrong units. Further liver function studies were equivocal but indicated liver damage.

X-rays.—Chest film, barium enema studies, and a gastrointestinal series were negative.

Hospital Course.—A diagnosis of obstructive jaundice was made and surgery advised. Owing to the general debility of this patient, some 18 days were devoted to preparation for definitive surgery.

Operation.—On Sept. 10, the abdomen was entered through a long right paramedian incision. Exploration established the diagnosis of obstructive

*I was then Chief Resident in Surgery at this institution.

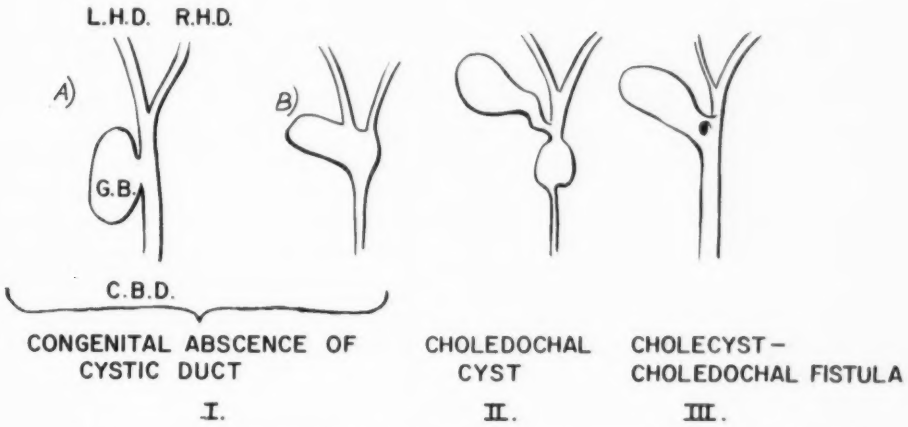


Fig. 1.—Of the situations pictured, perhaps *I-B* is most unusual, with *II*, *I-A*, and *III* following, in that order.

jaundice due to a common-duct stone. Considerable biliary cirrhosis was in evidence. After a tedious dissection, a small, leathery gallbladder was outlined. Perhaps two-thirds of its circumference was buried within the liver. A single large biliary calculus was palpable within the common duct. The dissection of the common duct was begun laterally near the duodenum. On approaching Hartmann's pouch, no plane could be found to separate the gallbladder and the common duct. The common duct was then opened, the large (2×3 cm.) pigment stone removed, and a No. 9 Bakes' dilator passed through the sphincter. Retrograde probing of the ducts was then carried out, thus determining the presence of a large communication between the gallbladder and the common duct. No cystic duct was detected, and a tentative diagnosis of congenital absence of the cystic duct was made (Fig. 1). With a probe passing through the common duct and into the right hepatic duct, the gallbladder was excised. As the gallbladder was lifted from its bed, the cystic duct was identified (still probe-patent) entering the superior aspect of the hepatic duct junction. Thus, the diagnosis was altered to cholecystocholedochal fistula. The defect following cholecystectomy involved both the common and the right hepatic duct. Repair was effected with the probe still in situ. Interrupted sutures of 0000 and 00000 black silk were used. Subsequent irrigation disclosed fluid leaks; therefore the suture line was reinforced by a pedicled graft composed of the falciform ligament, a fluid-tight closure resulting. A No. 22 T-tube was placed, as were drains, and the procedure was concluded (Fig. 2).

The postoperative course was uneventful. On the 14th postoperative day a T-tube cholangiogram revealed an intact biliary system. The T-tube was then removed. The patient showed progressive

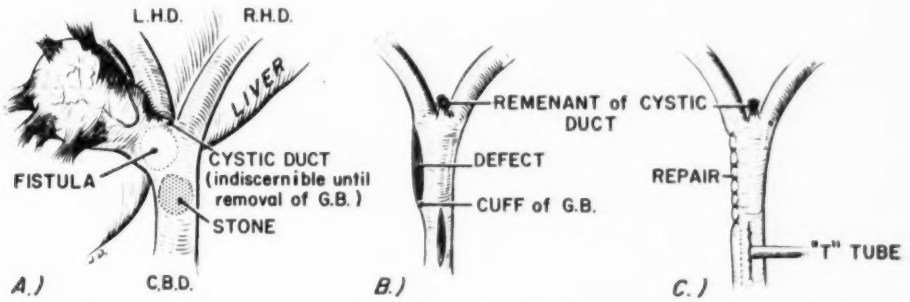


Fig. 2.—The situation encountered is seen in *A*. After excision, the defect is seen to involve the right hepatic and common ducts (*B*). Note high location of the cystic duct at the hepatic juncture. In *C*, one notes that the cuff of retained gallbladder was less than ideal, as closure compromised the duct lumen somewhat. The falciform ligament was then turned over this suture line and tacked down.

clearing of his jaundice. Now, two years later (Sept. 15, 1958), the patient is well.

Comment

The surgery of internal biliary fistulae is difficult, owing to the long-standing, severe pathology. Thus, retrograde probing of the biliary tree is a very useful procedure. If, in such probing, one encounters a wide communication between the gallbladder and the choledochus, one of three situations exists (Fig. 1).

The choledochal cyst is usually symptomatic at an early age and in the absence of biliary tract disease. The cyst and the gallbladder can both be identified. The accepted treatment, of course, is cystenterostomy.

The remaining situations may be initially confused after probing (as in the case reported), but the management can be reduced to a common procedure. The essence of this procedure is preservation of a cuff of gallbladder, to be used in reconstruction of the ductal system.

Rabinovitch and associates [3] have alluded to the problem of rare anomalies of the biliary tract, as has Braasch.[1]

Summary

A single experience with the unusual cholecystocholedochal fistula is documented. The operative diagnosis is considered and a method of repair illustrated. Cognizance of this lesion makes both diagnosis and repair simple.

Suite 304, 1720 Springhill Ave.

REFERENCES

1. Braasch, J. W.: Congenital Anomalies of the Gallbladder and Bile Ducts, S. Clin. North America, pp. 627-630 (June) 1958.

2. Marshall, S. F., and Polk, R. C.: Spontaneous Internal Biliary Fistulas, S. Clin. North America, pp. 679-691 (June) 1958.

3. Rabinovitch, J.; Rabinovitch, P.; Rosenblatt, P., and Pines, B.: Congenital Anomalies of the Gallbladder, Ann. Surg. 148:161-168, 1958.

Benign Retroperitoneal Mesenchymoma (Hamartoma)

H. RICHARD HELLSTROM, M.D., and EDWIN R. FISHER, M.D., Pittsburgh

Retroperitoneal cysts are rare, approximately 70 such lesions having been recorded.[1] Examples have been classified as (1) lymphatic, (2) enteric, (3) urogenital, (4) teratoid, (5) parasitic and inflammatory, and (6) traumatic.[2] The vast majority of these cysts have been considered to be lymphatic in origin,[1,3-7] and have variously been termed chylous cysts,[2,3,6,8] lymphatic cysts,[9,10] or cystic lymphangiomas.[1,5]

These tumors are usually asymptomatic, and most frequently present as an abdominal mass.[1,2] Occasionally, the symptoms of intermittent partial intestinal obstruction, peripheral edema, or poorly localized abdominal pain may occur as a result of pressure on bowel, blood vessels, or nerves.[2] Rarely, torsion of the pedicle of the cyst may result in acute abdominal pain, simulating other abdominal catastrophes.[1,2]

The purpose of this report is to describe a retroperitoneal cyst formed predominantly of lymphangiomatous elements, but which contained other structures, such as arteries, veins, nerves, lymph follicles, and fat, as integral parts of the mass. The patient had a one-month history of intermittent abdominal pain and a palpable abdominal mass. The resected specimen, which was supported by a short pedicle, showed evidences of vascular compromise. Information derived from pathologic study appears pertinent to an understanding of the nature and identity of these retroperitoneal lesions.

Report of Case

A 65-year-old white man was admitted to the Veterans Administration Hospital with a one-month history of intermittent midabdominal cramping pain. There were no other symptoms referable to the gastrointestinal tract. Physical examination revealed a 10 cm., highly mobile, nontender, firm, smooth mass in the left upper abdomen. The physical examination was otherwise noncontributory. X-ray studies revealed the mass to be extrinsic to the gastrointestinal tract. It displaced the colon downward, and the stomach was indented along its lesser curvature and displaced anteriorly, downward, and to the left. Operation revealed a smooth ovoid mass which lay in the lesser omental bursa, displacing the stomach downward and anteriorly. It lay between the gastrohepatic ligament and the pancreas and was supported by a short pedicle. The lesion was resected *in toto* without incident, and the postoperative course was uneventful.

Submitted for publication Dec. 1, 1958.

From the Departments of Pathology, University of Pittsburgh School of Medicine and Veterans Administration Hospital.

Pathologic Findings

Gross Examination.—The specimen consisted of an encapsulated, firm, ovoid mass, measuring 20×10×5 cm. Its smooth external surface was bosselated with dark-red cysts, which measured 1.5 to 4.0 cm. The cut surface was honeycombed with multiple cysts, which measured 0.5 to 5.0 cm. and contained yellow or bloody fluid. Some were filled with blood clot.

Microscopic Examination.—Sections revealed a mesenchymal tumor formed of fibrous and fatty tissue, containing many cystic spaces (Fig. 1). Most of these were lined with simple endothelium, supported by a thin layer of dense collagenous stroma and well-formed smooth muscle. Many of these cystic spaces were filled with acellular granular material, but some contained red blood cells. Partially organized thrombi were not infrequent (Fig. 2). Granulation tissue, macrophages, and lymphocytes were evident in the stroma adjacent to the organizing blood clots. Smaller, thin-walled, cavernous spaces contained granular amorphous material, or red blood cells, or mixtures of amorphous material and cells. Large muscular arteries, with a well-defined internal elastic lamina, as revealed by the Verhoeff-Van Gieson elastic stain, were present. Large veins and multiple, various-sized peripheral nerves were encountered frequently (Fig. 3). Small lymphoid aggregates were scattered in the stroma and in the walls of the larger vascular spaces. A portion of a well-formed lymphoid aggregate had undergone cavernous trans-

Fig. 1.—Smooth muscle is seen in the wall of a large vascular space. An artery and a nerve are present in the stroma. Reduced to 83% of mag. × 120.

formation, and both granulation tissue and red blood cells were present within the vascular spaces.

Comment

The prominent vascular structures encountered in the lesion described are highly reminiscent of those encountered in some angiomas of blood-vessel and lymphatic origin. Nevertheless, the equally outstanding mature adipose and neural components warrant its designation as a benign mesenchymoma, a term utilized by Stout[11] for tumors comprised of two or more mature mesenchymal tissues, fibrous tissue excluded. Since the lesion presented here appears to represent the morphologic prototype of the majority of previously recorded retroperitoneal cysts, particularly those designated as lymphangiomas,[1,5] it is considered that the benign mesenchymoma represents the

Fig. 2. — Large cystic spaces, one of which contains a partially organizing blood clot. There are collections of macrophages and lymphocytes in the fibrofatty stroma. Reduced to 83% of mag. × 30.

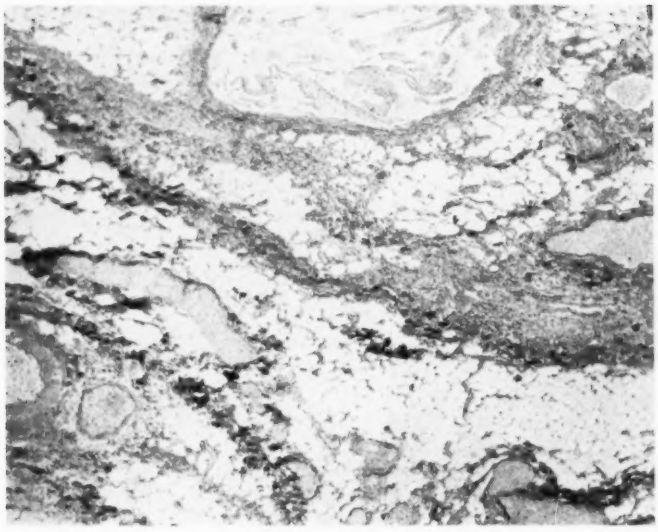


Fig. 3. — An artery, vein, and several large nerve segments within the tumor. Reduced to 83% of mag. × 60.

common tumor at this site. Such an interpretation does not exclude the existence of genuine vascular neoplasms in the retroperitoneal space, since well-documented examples of angiosarcoma [4] and hemangiopericytoma,[4,11] as well as hemangioma [12-17] and lymphangioma,[18] have been recorded.

The term mesenchymoma also appears appropriate with respect to the nature of this lesion. The occurrence of mature adipose tissue and neural elements, as well as vascular structures with well-formed muscular walls, is in keeping with a hamartoma [19]—a purposeless overgrowth of mature tissue indigenous to a particular area—rather than a true neoplasm. The term mesenchymoma possesses more descriptive specificity than the latter and avoids the "mystery and confusion" associated with its meaning.[11]

The presence of organized thrombi and areas of infarction within this retroperitoneal tumor undoubtedly represents the result of torsion of its pedicle, which episode may be considered the cause of the acute abdominal pain experienced by this patient.

Summary

The clinical and pathologic findings in a case of a benign retroperitoneal mesenchymoma are presented. The tumor was essentially a cystic lymphangioma, but the presence of other mature tissue elements, such as adipose tissue, arteries, veins, and nerves, indicate its hamartomatous origin. The term mesenchymoma represents an appropriate designation for such retroperitoneal tumors.

Abdominal pain experienced by the patient presented was related to torsion of the vascular stalk of the tumor.

Veterans Administration Hospital, University Dr. (40).

REFERENCES

1. Harrow, B. R.: Retroperitoneal Lymphatic Cyst (Cystic Lymphangioma), J. Urol. 77:82-89, 1957.

2. Simon, H. E., and Williamson, B.: Retroperitoneal Chylous Cysts, Am. J. Surg. 91:372-376, 1956.

3. Beahrs, O. H.; Judd, E. S., Jr., and Dockerty, M. B.: Chylous Cysts of the Abdomen, S. Clin. North America 30:1081-1096, 1950.

4. Ackerman, L. V.: Tumors of the Retroperitoneum Mesentery and Peritoneum, in U. S. Armed Forces Institute of Pathology: Atlas of Tumor Pathology, Section VI, Fascicles 23 and 24, 1954.

5. Kretschmer, H. L., and Hibbs, W. G.: Retroperitoneal Perirenal Lymphangioma, Arch. Surg. 29:113-125, 1934.

6. Gerster, J. C. A.: Retroperitoneal Chyle Cysts, with Especial Reference to the Lymphangiomata, Ann. Surg. 110:389-410, 1939.

7. Melicow, M. M.: Primary Tumors of the Retroperitoneum: A Clinicopathologic Analysis of 162 Cases, J. Internat. Coll. Surgeons 19:401-449, 1953.

8. Lee, F. C.: Large Retroperitoneal Chylous Cyst: Report of a Case, with Experiments on Lymphatic Permeability, Arch. Surg. 44:61-71, 1942.

9. Pack, G. T., and Tabah, E. J.: Primary Retroperitoneal Tumors: Study of 120 Cases, Collective Review, Internat. Abstr. Surg. 99:209-231; 313-341, 1954; in Surg. Gynec. & Obst. Sept., Oct., 1954.

10. Newman, H. R., and Pinck, B. D.: Primary Retroperitoneal Tumors: A Summation of 33 Cases, Arch. Surg. 60:879-896, 1950.

11. Stout, A. P.: Tumors of the Soft Tissue, in U. S. Armed Forces Institute of Pathology, Atlas of Tumor Pathology, Section II, Fascicle 5, 1953.

12. Newman, H. R., and White, R. R.: Retroperitoneal Hemangioma, J. Urol. 79:811-814, 1958.

13. Hilse, A.: Über retroperitoneale mesodermale Geschwülste mit einem Beitrag zu ihrer Morphogenese, Arch. klin. Chir. 150:251-258, 1928; cited by Newman.[12]

14. Harris, A.: Retroperitoneal Angioma: A Review of the Literature on Perirenal Tumors, J. Urol. 21:181-192, 1929.

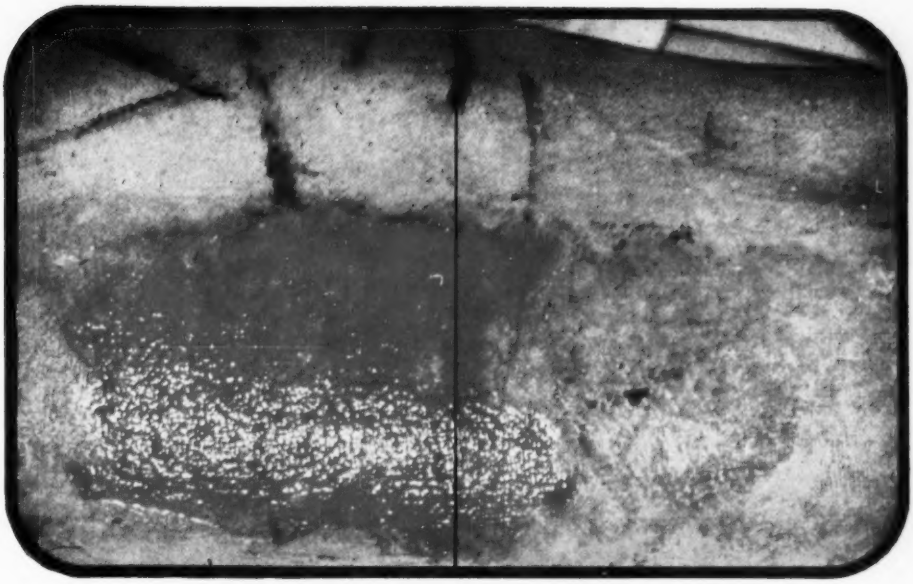
15. Millman, M.: Retroperitoneal Cavernous Hemangioma, J. A. M. A. 124:773-774, 1944.

16. Aurelius, J. R.; Peterson, D. H., and Niknejad, I.: Retroperitoneal Cavernous Hemangioma Associated with Hemangiomas of the Skin in a Newborn, Minnesota Med. 38:32-37, 1955.

17. Ward, G. E., and Stewart, E. H., Jr.: Retroperitoneal Cavernous Hemangioma, Am. J. Surg. 80:470-472, 1950.

18. Dacso, M. R., and Angrist, A. A.: Retroperitoneal Bilateral Cavernous Lymphangioma in a Patient with Congenital Heart Disease, A. M. A. Arch. Path. 50:623-631, 1950.

19. Albrecht, P.: Verhandl. deutsch. path. Gesellsch. 7:153, 1904 cited by Willis, R. A.: Pathology of Tumours, Ed. 2, St. Louis, C. V. Mosby Company, 1953, Chap. 1, p. 7.



Skin graft donor site after 2 weeks' treatment with ...

petrolatum gauze—still largely granulation tissue | FURACIN gauze—completely epithelialized

OBJECTIVE EVIDENCE OF EXCELLENT WOUND HEALING

was obtained in a quantitative study of 50 donor sites, each dressed half with FURACIN gauze, half with petrolatum gauze. Use of antibacterial FURACIN Soluble Dressing, with its water-soluble base, resulted in rapid and complete epithelialization. No tissue maceration occurred in FURACIN-treated areas; no sensitization was reported.

Jeffords, J. V., and Hagerty, R. F.: Ann. Surg. *145*:169, 1957.

FURACIN® . . . brand of nitrofurazone

a broad-range bactericide that is *gentle to tissues*

spread FURACIN Soluble Dressing: FURACIN 0.2% in water-soluble ointment-like base of polyethylene glycols.

sprinkle FURACIN Soluble Powder: FURACIN 0.2% in powder base of water-soluble polyethylene glycols. Shaker-top vial.

spray FURACIN Solution: FURACIN 0.2% in liquid vehicle of polyethylene glycols 65%, wetting agent 0.3% and water.

EATON LABORATORIES, NORWICH, N.Y.

Nitrofurans—a NEW class of antimicrobials—neither antibiotics nor sulfonamides

YOUR
GUIDE TO
CURRENT PUBLICATIONS

Quarterly Cumulative Index Medicus

WITH AUTHORS AND SUBJECTS . . .

Divided into sections, one devoted to books and the other to periodical literature, the QUARTERLY CUMULATIVE INDEX MEDICUS contains a list of current publications alphabetized as to authors and subjects. The exact bibliographic reference is given under the author with titles in the original language, while titles under subjects are all in English. The index also includes a listing of journals, addresses and publishers.

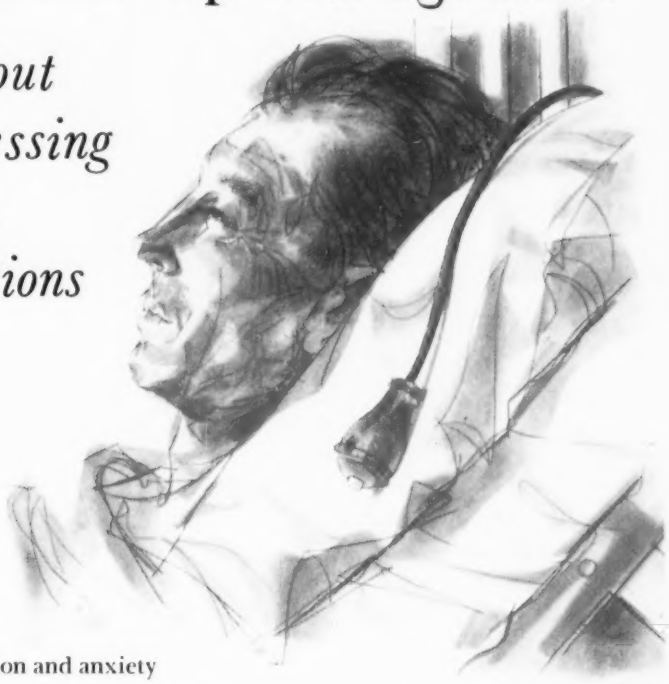
The QUARTERLY CUMULATIVE INDEX MEDICUS appears twice a year; volumes are cloth bound and cover periodicals for six months as indicated on the publication. These two volumes will be a convenient and inclusive reference for current medical literature. Invaluable for practitioners, specialists, teachers, editors, writers, investigators, students and libraries.

SUBSCRIPTION PRICE $25.00 PER YEAR
CANADIAN AND FOREIGN $27.00 PER YEAR

AMERICAN MEDICAL ASSOCIATION
535 NORTH DEARBORN STREET
CHICAGO 10, ILLINOIS

Relieves Pre-op Apprehension Aids Post-op Management

without depressing vital functions



- relieves tension and anxiety
- helps provide "a good night's sleep"
- facilitates early ambulation
- relaxes skeletal muscle

Miltown has no adverse effects on cardiovascular, respiratory or gastrointestinal functions and causes no depressive "hang-over"

Miltown®
meprobamate (Wallace)

Miltown is available in 400 mg. scored and 200 mg. sugar-coated tablets; bottles of 50.

WALLACE LABORATORIES
New Brunswick, N. J.

Reprints available on request:

1. Kern, E. C.: Preoperative sedation with meprobamate (Miltown) in surgery of eye, ear, nose and throat. Eye, Ear, Nose & Throat Month. 36:408, July 1957.
2. Lamphier, T. A.: The value of meprobamate preoperatively. Maryland M.J. 7:627, Nov. 1958.
3. Lamphier, T. A.: Meprobamate—an important adjunct to post-operative surgical care. J. Maine M.A. 48:357, Oct. 1957.
4. Lamphier, T. A.: The role of meprobamate in postoperative surgical care. Ann. New York Acad. Sc. 67:810, May 9, 1957.
5. Rushia, E. L.: Preliminary report on the use of meprobamate for pre-anesthetic sedation. J.M.A. Georgia 46:93, March 1957.
6. Sadove, M. S. and Schiffrin, M. J.: Tranquilizers in surgery, in Surg. Clin. North America, Saunders, Philadelphia, Feb. 1959, pp. 231-244.

CM-8879

Electron Beam Sterilized

SUTUPAK® surgical silk

dry, pre-cut, sterile

stronger, better "hand"

Because the exclusive Ethicon electron beam sterilization process involves no heat, there is no melting and setting of wax... suture remains free of trauma producing "crust," "baked in" bends, "bumps" from loosened weave. New "tear open" foil packet delivers your suture dry, pre-cut, sterile... at full tensile strength.

ETHICON®

Viokase Pancreatin 4 times the N.F. X minimum potency standards.

VIOKASE

CONFORMS TO PHYSICIANS COUNCIL CODE FOR ADVERTISING

WHOLE PANCREAS
Not an extract!

EFFECTIVE substitution therapy in demonstrated pancreatic deficiency.

NOT ENTERIC COATED

Jordan and Grossman; Arch. Surg. 74: 871, 1957

Shingleton, et al; Surgery, 42: 12, 1957

Longmire, Jordan and Briggs; Ann. Surg. 144: 681, 1956

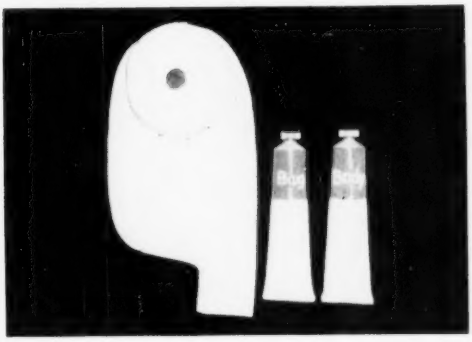
Krane; Am. Pract. and Digest, 8: 1275, 1957

Literature on request.

VIOBIN, Monticello, Illinois

CUSTOM MADE

RUBBER ILLEOSTOMY COLOSTOMY APPLIANCES



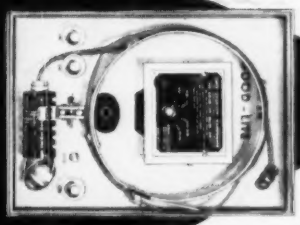
- CHEMICALLY TREATED TO HELP ELIMINATE ODOR.
- CEMENTED TO BODY WITH OUR SPECIAL ADHESIVE CEMENT.

For information write to:

GERARD PRODUCTS
Dept. A
7875 Oakleaf Ave., Elmwood Park, Chicago 35, Ill.

new SUPER HEADLIGHT

BY GOOD-LITE



- *COOLER OPERATION*
- *9 INTENSITIES OF LIGHT*
- *INCREASED SAFETY— UNDERWRITERS APPROVED*

Medical men who have tried the new Super Good-Lite tell us there's nothing like it anywhere . . . at any price! Here's why: The entire unit has been redesigned by a group of *practicing surgeons* to provide a beam of light both brilliant and controllable . . . featuring nine intensities of light. The headlight construction and electrical circuit was designed for cooler operation and maximum safety.

The Good-Lite SUPER Headlight Includes:

- Good-Lite parallel beam headlight.
- 3 types of bulbs with 3 intensities of light each.
- Special Ground lens to intensify light.
- 2 mirrors (peep-hole and plain).
- Heavy duty transformer (20 watt) with 3 positions and off switch. Fuse in the secondary for your safety.
- Molded plastic connections.
- Gray plastic stainproof cords.
- Choice of 5 types of headbands.

Consult Your Surgical Supply Dealer or Send Coupon Today

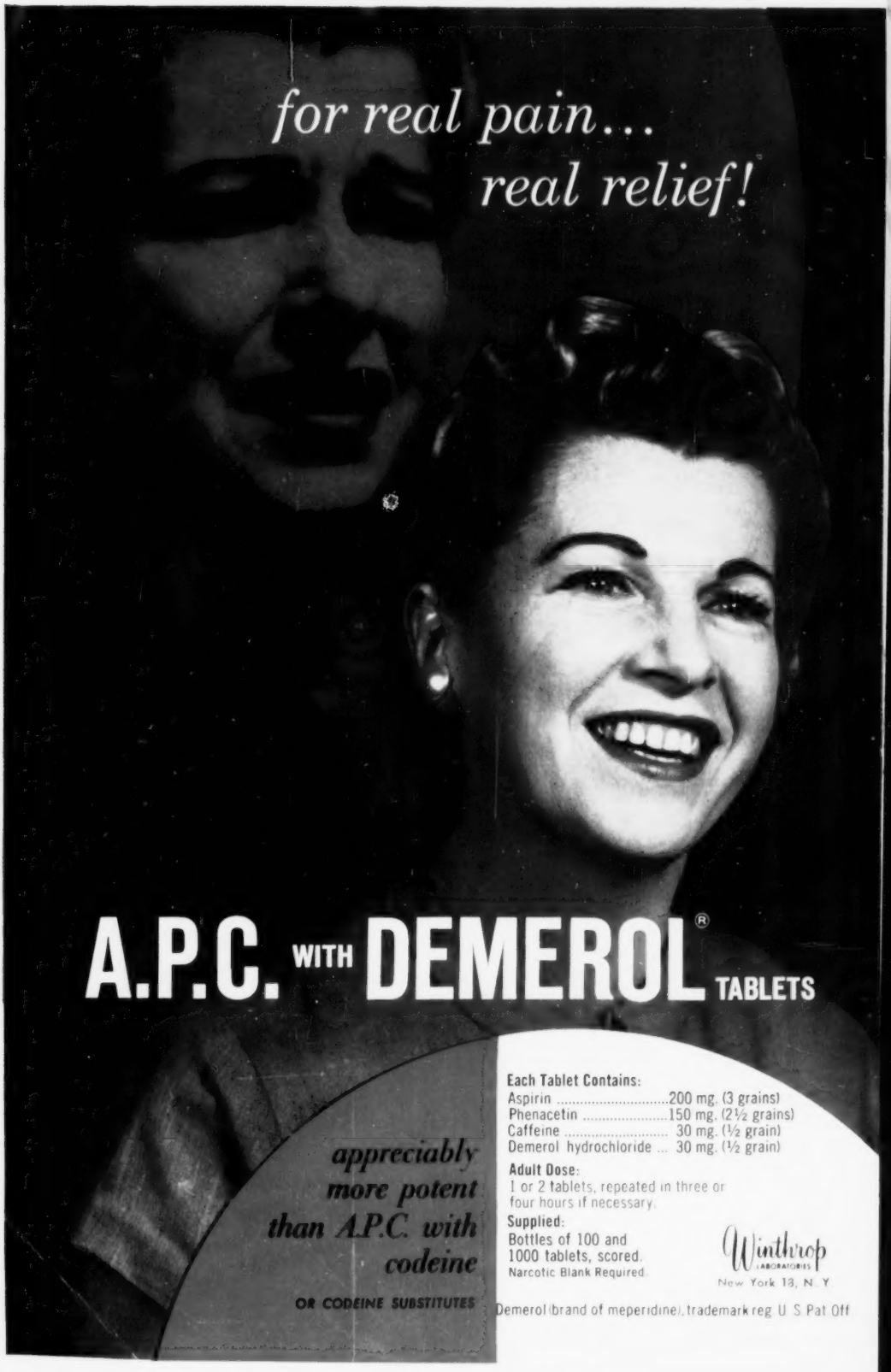
GOOD-LITE MFG. CO.
7638 W. Madison St. • Forest Park, Ill.

Please send free catalog on Good-Lite Headlights to:

Dr. _____

Address _____

City _____ Zone _____ State _____


for real pain...
real relief!
A.P.C. WITH DEMEROL® TABLETS
appreciably more potent than A.P.C. with codeine
OR CODEINE SUBSTITUTES
Each Tablet Contains:
Aspirin .....200 mg. (3 grains)
Phenacetin .....150 mg. (2½ grains)
Caffeine ..... 30 mg. (½ grain)
Demerol hydrochloride ... 30 mg. (½ grain)
Adult Dose:
1 or 2 tablets, repeated in three or four hours if necessary.
Supplied:
Bottles of 100 and 1000 tablets, scored.
Narcotic Blank Required.
Winthrop LABORATORIES
New York 18, N. Y.
Demerol (brand of meperidine), trademark reg. U. S. Pat. Off.